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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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See page 78. 5020

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See Advertisement page 26. 4900

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Two Galloway's SUPERHEATERS.
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See Advertisement page 36, Jan. 21. 2402

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WEIGHING MACHINES. — EAST FERRY ROAD ENGINEERING WORKS COMPANY, LIMITED, LONDON, E.—Hydraulic Cranes, Grain Elevators, &c. See Illus. Advt. last week, page 17. 4812

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Wanted, One Four Wheel
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For Sale, One Two-Spindle
"Newton" PROFILING MACHINE, hand feed, similar to No. 12 Pratt & Whitney. Complete with countershaft and pulleys. Brand new. Not yet unpacked.—Apply for full particulars and price to TILLING-STEVENS, LTD., Victoria Works, Maidstone, Kent. D 428

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NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

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See half-page Advertisement page 62, Jan. 28.

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For Particulars of Course of Instruction by Correspondence, write to "The Westminster Engineering Bureau," 23, Old Oak Road, Acton Park, London, W. 4321

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Chinese Government Railways.

Canton Hankow Railway (Hupei-Hunan Section.)

Tenders are Invited for:—
75 High Sided 30 ton STEEL BOGIE FREIGHT CARS,
75 Low Sided 30 ton STEEL BOGIE FREIGHT CARS,
for the above Railway.
Conditions of Tender, Drawings and Specifications may be obtained from the Consulting Engineers, Messrs. C. P. Sandberg, Palace Chambers, 9, Bridge Street, Westminster, S.W., on payment of 10s.
Tenders to be delivered to Messrs. C. P. SANDBERG before Eleven a.m. on 11th March, 1916. D 563

Re THE EMPIRE PORTLAND CEMENT CO., Ltd.

The Receiver appointed by the Debenture Holders of the above Company invites
Tenders for the Sale of the Lease of the Company's Premises at Northfleet, Kent, and the other Assets of the said Company comprised in the Debenture Holders' security. The Purchaser can by arrangement take over certain Contracts entered into by the Company. The said Lease and Contracts, or copies thereof, can be seen, and full particulars can be obtained, at the Receiver's Office, and any party tendering shall be assumed to have full knowledge of the contents of such Lease and Contracts whether inspecting the same or not. Tenders must be delivered at the said Office before Four o'clock on Wednesday, the 16th instant, and the Purchaser whose Tender is accepted must satisfy the Lessors as to his responsibility.
Dated this 9th day of February, 1916.
C. Albert Radermacher (Receiver),
36, Camomile Street,
London, E.C. D 502

The Cheshire Lines Committee are prepared to receive
Tenders for the Purchase and Removal of the whole of the Second-hand Plant and Materials, comprising the Two 6-ton Steam Travelling Cranes, and the Girder Work and Cast-iron Columns forming the Gantry Structure on which they travel, now standing in the Victoria Yard, Huskisson Goods Depot, Liverpool.
Form of Tender and full particulars can be obtained upon application to Mr. Harry Blundell, Engineer, Cheshire Lines Committee, Central Station, Liverpool, on and after 10th February, 1916.
Sealed Tenders, endorsed "Tender for Second-hand Cranes," must be sent addressed to the undersigned, Great Northern Board Room, King's Cross Station, London, so as to be received not later than Nine a.m., on Monday, 6th March, 1916. D 553
Glegge Thomas,
Secretary.

Westport Harbour Board.

Dominion of New Zealand.

Tenders for Bucket Dredger and Steam Hopper:—
Tenders will be received until Noon of 2nd March, 1916, at the Office of the High Commissioner of the Dominion of New Zealand, Westminster Chambers, 13, Victoria Street, London, S.W., for the Construction and Delivery of one Bucket Dredger, and of one Steam Hopper Barge, for the Westport Harbour Board, New Zealand.
General Conditions of Contract, outline Specification, Form of Tender, &c., may be obtained by bona fide Tenderers on application to the Office of the High Commissioner, and payment of a deposit of £2 2s. Tenders will be considered only from firms of standing, accustomed to the building of vessels of the kind; they must be on the Board's Form of Tender, and must be accompanied by plans and detailed specifications.
Tenders, which must be separate for each vessel, must be addressed to the Westport Harbour Board, care of the High Commissioner, and endorsed either "Tender for Westport Dredger," or "Tender for Westport Hopper." The lowest or any Tender will not necessarily be accepted. D 443
(Signed) Charles Greenland,
Secretary.

APPOINTMENTS OPEN.

Assistant Estimating Clerk required, for munition works in Waltham stow. Preference given to those with some workshop experience and technical training, and able to collect figures and prices for estimating in connection with small part repetition work.
No one engaged on Government work need apply. State age, qualifications and salary expected.
Apply to your nearest LABOUR EXCHANGE, quoting No. A 1454. D 544

Dewsbury Union.

To Engineers.

Chief Engineer.

Wanted, Engineer, Mechanical and Electrical, to take charge of two Lancashire Boilers, two Vertical Engines, about 30 HP. each, with Dynamo and Storage Battery, also Electrical Installation throughout the Institution, together with the Heating and Hot Water arrangements.
Applications to be made on Forms to be obtained from the undersigned, stating wages required, and returned not later than Wednesday, the 16th inst.

Assistant Engineer.

WANTED, an ASSISTANT ENGINEER to the above, at the wages of 32s. weekly, with a War Bonus of 2s. weekly additional.
Applications to be made on Forms to be obtained from the undersigned, and returned not later than Wednesday, the 16th inst.
C. P. Pickersgill,
Clerk to the Guardians.
Union Offices,
Wellington Street, Dewsbury.
4th February, 1916 D 545

Engineer to Take Charge of small general fitting shop near Birmingham; experience of all kinds of machining, electric motors, lamps, gas engines and hydraulic plant necessary. Only experienced men need apply, and providing they are not on Government work; give full particulars age and wage required.—Apply, nearest LABOUR EXCHANGE, mentioning this Journal and D 575.

Young Mechanical Engineer, unmarried, REQUIRED, for British engineering firm in North China. Must have good training and varied experience; some commercial knowledge advisable; good pay and prospects.—Write, giving full particulars and copies of testimonials, to Y. Z., care of J. W. Vickers & Co., Ltd., 5, Nicholas Lane, E.C. D 558

Gentleman, with Intimate knowledge of and entrée to engineering firms, permanently REQUIRED; salary and commission; good openings.—Apply, the MANAGER, The Standard Catalogue Publishing Co., 26, Hart Street, Holborn, W.C. D 573

Representative Wanted, with engineering knowledge, for Yorkshire district, by large engineering firm. Good prospects for suitable man. State age, experience, and salary required.—BOX 143, Smith's Agency, Ltd., 100, Fleet Street, London, E.C. D 538

Wanted, Immediately, a Jig and TOOL DESIGNER, or a first-class TOOL MAKER, with some experience in making own designs. Preference given to man with experience of High Explosive Shell production.
No person on Government work will be engaged.
Apply your nearest LABOUR EXCHANGE, quoting this Journal, and No. A 1451. D 532

Designers and Draughtsmen WANTED for Rigid Airship work. Light structural and mechanical or aeroplane experience an advantage.—Apply, stating age, experience and salary, to the nearest BOARD OF TRADE LABOUR EXCHANGE, mentioning this paper and No. A 1442. No person on Government work will be engaged. D 533

Clerk Wanted, in Walthamstow to keep records of piece-work prices. One with knowledge of automatic screw machine products preferred. No one engaged on Government work need apply.—State age, qualifications, and salary expected to your nearest LABOUR EXCHANGE, quoting No. A 1457. D 547

Leading Draughtsman.—POSITION REQUIRED by capable Designer (shop trained); exceptional wide experience in high-speed petrol motors, also aeronautical experience.—Address, D 584, Offices of Engineering.

Air Department, Admiralty.

Wanted, Mechanical DRAUGHTSMAN, for aeroplane work in the Admiralty. Man with experience in detailing motor-car parts preferred.
No person already employed on Government work will be engaged.
Apply, in writing, enclosing references, to—
Director Air Services,
Air Department,
Admiralty,
marking envelopes, "D Section." D 579

Wanted, at Once, thoroughly Capable Textile DRAUGHTSMAN, with experience in dyeing and finishing machinery. Permanency. Applicants must be ineligible for military service.—Address, stating age, experience, and salary required, D 561, Offices of Engineering.

Wanted, for Temporary Engagement, a DRAUGHTSMAN, to prepare plans, &c., for the construction of an electricity generating station.—Applications, stating age, experience, salary required, and when at liberty, accompanied by copies of two recent testimonials, to be addressed to the BOROUGH ELECTRICAL ENGINEER, Eccles Corporation Electricity Works, Cawdor Street, Patricroft, Lancs. D 577

Draughtsman Required, by engineering works controlled by Government, S. London; marine engineering experience preferable. Ineligible for military service. No person already employed on Government work can be engaged.—Applicants must apply nearest BOARD OF TRADE LABOUR EXCHANGE, mentioning this Journal and D 548.

Wanted, Immediately, for Government work, experienced DRAUGHTSMEN for switch-gear work, controller work and jig and tool work. No one already engaged on Government work need apply.—Write full experience, qualifications and salary required, to your nearest LABOUR EXCHANGE, quoting No. A 1447. D 513

Wanted, Draughtsman for electrical war work, shop experience necessary; preference given to those with searchlight experience. No man on Government work need apply.—Apply, your nearest LABOUR EXCHANGE, quoting No. A 1462. D 581

Draughtsmen.—One or Two WANTED, for steam turbine work; Midland district. No person at present employed on Government work will be engaged.—Apply, with full information regarding experience, salary and age, to nearest LABOUR EXCHANGE, mentioning this paper, and D 541.

Draughtsman.—Young Man, for high-speed engine and centrifugal pump works. No person already employed on Government work will be engaged.—State age, wage, and experience to nearest LABOUR EXCHANGE, mentioning this Journal and D 543.

Structural Draughtsman (ineligible) REQUIRED, must be experienced designer in steel-framed buildings, roofs, bridges, &c. No person already employed on Government work will be engaged.—Apply, stating age, experience, and salary expected, to nearest LABOUR EXCHANGE, mentioning this Journal, and D 560.

Foreman, with Special Experience in loam, for London ironfoundry engaged on Government work; must be thoroughly experienced. No one already on Government work need apply.—Write, stating age, experience, and salary required, to your nearest LABOUR EXCHANGE, mentioning this paper and No. 1314. D 574

Wanted, Immediately, by a large firm of dynamo manufacturers in Manchester district, first-class MACHINE SHOP FOREMAN. Must be good organiser, and able to handle men successfully. No person already employed on Government work will be engaged.—State experience, salary required, and when at liberty, to nearest LABOUR EACHANGE, mentioning this Journal, and D 576.

Working Foreman for Small brass finishing shop (50 hands), engaged on munition work, used to accurate work and control of very small drilling, tapping and milling machines; female labour. Permanent position, and good prospects for suitable man, capable of getting the work through shop.
Write, stating age, experience, and wages required, to your nearest LABOUR EXCHANGE, quoting No. A 1455. No person on Government work will be engaged. D 545

Wanted, for a Government controlled commercial motor vehicle factory in the West Riding District, a CHARGE HAND or FOREMAN over the automatic section. Must have had previous experience in a similar capacity with Potter & Johnston, Herbert's, Gridley and Cleveland Automatics. Also TWO INSPECTORS for View Room, preferably with experience of automobile details.—Applicants must write or apply to the nearest BOARD OF TRADE LABOUR EXCHANGE, mentioning this paper and No. A 1446, and giving full particulars of their experience, age and wages required. No man at present engaged on Government work need apply. D 502

Experienced Man Required, to take charge of engineers' raw material, finished part and tool stores; first-class experience essential. Applicants should give full particulars of past experience, and state age, salary required and when disengaged. No one on Government work need apply.—Apply, your nearest LABOUR EXCHANGE, quoting No. A 1477. D 578

Extrusion Plant.—Fully experienced MAN REQUIRED, to take charge of a brass extrusion plant. No man who is employed on Government work need apply.—Address, D 572, Offices of Engineering.

Tool-maker or Improver REQUIRED, in munition works. Capable of making small drills and taps, and setting small machines. No one on Government work need apply.—State full particulars to your nearest LABOUR EXCHANGE, quoting No. A 1456. D 546

Wanted, Leading Turner, as charge hand for 9 in. centre lathe and vertical boring machines for urgent Admiralty work, London district. Progressive position to right man for quantity production. No man on Government work need apply.—Apply, your nearest LABOUR EXCHANGE, quoting No. A 1461. D 580

Munition Factory Requires several JIG and TOOL MAKERS, also INSTRUMENT MAKERS and TURNERS, willing to learn to Operate and Set-up Cleveland, Gridley, and Brown and Sharpe automatic machines. No person already engaged on Government work will be considered.—Apply, in first case, to the nearest LABOUR EXCHANGE, mentioning this Journal and C 870.

Engineering Pupil.—Vacancy with Firm (Government Contractors) manufacturing latest types of machinery, oil and gas engines, &c.; moderate premium.—Address, 6521, Offices of Engineering.

Pupil. — The Borough and Waterworks Engineer (A.M.I.C.E.), of Leamington, has a VACANCY in his office for a PUPIL.—Address, TOWN HALL. C 342

A Large Firm of Engineers, in the Midlands, have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4350, Offices of Engineering.

SITUATIONS WANTED.

Chemical Works Manager, experienced mechanical and electrical engineer, with good knowledge of chemistry both in theory and practice, now disengaged, DESIRES suitable POST. Age 45 years. Practical experience extending over 30 years in England and on the Continent. Fluent in three languages, besides English.—Address, D 537, Offices of Engineering.

Works Manager, thoroughly experienced in all departments of manufacture, hyd., marine, elect., loco., and general engineering work, recently for several years engaged with large (controlled) firm producing munition parts for Admiralty and War Office, previously held similar positions, is OPEN for immediate ENGAGEMENT. Salary £550/£600.—D 594, Offices of Engineering.

Officer (temporary) Royal Engineer, invalided from Service but quite fit for civilian work, DESIRES immediate EMPLOYMENT. Is an Assoc. M. Inst. C.E. and B.Sc. (Eng.), London. 12 years' experience in railway work, bridges and general structural steelwork; office work, designing and charge of works.—D 586, Offices of Engineering.

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THE NOMENCLATURE OF INTERNAL-COMBUSTION ENGINES.

As is perhaps natural with any new type of prime mover, the nomenclature of the various engines which fall under the general heading of internal-combustion engines, as well as the names which different builders allot to similar parts of their products, are diverse, and in some cases distinctly unsuitable. A general review of this question, together with some suggestions towards standardisation in nomenclature, may therefore be regarded as timely.

As a general heading for the types under consideration, "Internal-Combustion Engines" is satisfactory in that it conveys the idea of combustion of the fuel within the engine itself. Since this title applies to many different classes of engine, it is not too clumsy for the purpose for which it is used—namely, that of general description. With the denomination "gas-engines," from whatever source the gas is derived, no ambiguity so far can arise. If, however, petrol and similar engines, as later explained, were rightly included under the heading of gas-engines, difficulties might occur.

As distinguishing a type of engine, the names of persons are always unsatisfactory as being generally, to the uninitiated, totally void of description. In stating the cycle upon which most internal-combustion engines work, the designation "Otto" or "Beau de Rochas" cycle has almost entirely given place to the descriptive term "Four-stroke-cycle," abbreviated for convenience often into "Four-cycle," as opposed to the "Two-stroke-cycle" or "Two-cycle." In connection with the Diesel oil-engine efforts have been made abroad and at home to take from the late Dr. Rudolf Diesel the credit of being the inventor of this type of oil-engine. Whether or not Diesel was the first to conceive the idea of an engine in which the heat generated by the compression of air on the up-stroke of the piston ignites the fuel injected at about the top dead centre—and it is not questioned herein—is not the point of paramount importance. Certain it is that his realisation and conviction of the future possibilities of such an engine were so strong that he succeeded in inducing the firms of Fried. Krupp, of Essen, and the Maschinenfabrik, of Augsburg, to make experiments, under his guidance, culminating in 1897 in an engine resembling greatly the standard vertical four-cycle Diesel engine of the present time. On this account, it is not unjust that, if it should be necessary to associate any name with this type of oil-engine, the name should be Diesel. The extent to which the type of engine bearing this name has been generally exploited in some measure removes the objection, already stated, to the use of personal names. Whilst this is so, it is admittedly desirable, if possible, to obviate the use of such names. To this end, Diesel engines are often named simply "heavy-oil engines." For some time past, however, there have been built oil-engines which are not Diesel engines as defined herein, but which can, however, burn fuel oils of a heavier nature than paraffin. For competitive purposes, these other engines were also sometimes called "heavy-oil engines." There have also been instances of engines other than the Diesel type claiming to be heavy-oil engines, which would only run satisfactorily on paraffin or light shale oil. Diesel engines, therefore, were called "heavy-oil engines (Diesel system)." Grave objections can be lodged against the name "oil-burning engines," for the name gives no clue to the nature of the oil burnt nor to the manner in which combustion takes place.

Turning to a consideration of the Diesel cycle for inspiration for a title suitable for such engines, the following are suggested :—

High-Compression Oil-Engine,
Constant-Pressure Combustion Oil-Engine,
Positive-Combustion Oil-Engine,
Automatic-Combustion Oil-Engine,
Air-Injection Oil-Engine.
Slow-Combustion Oil-Engine.

Of these, that of the "high-compression oil-engine" is, perhaps, the most suitable. This title is taken to mean, then, that the compression is carried to a sufficient extent to ignite heavy oil injected into the cylinder at about the top dead-centre. The "constant-pressure combustion oil-engine" is a sufficiently correct theoretical designation, although Diesel engines can work perfectly well when the combustion is not at constant pressure, and there are engines working on principles differing from the Diesel cycle with which indicator diagrams showing the feature of constant-pressure combustion can be obtained. "Positive" and "automatic combustions" are not happy terms, and might also be applied to other engines. "Air-injection oil-engine" is unsuitable, since there are Diesel engines which dispense with air injection, and there have been hot-bulb engines with air injection of the fuel. The term "slow-combustion oil-engine" merits more than a passing reference. Undoubtedly, with the Diesel principle, the complete ignition of the total charge of fuel oil is not instantaneous, since the injection of the mixture of fuel oil and air takes place throughout an appreciable part (some 10 per cent.) of the piston stroke. The mixture, as it enters the cylinder combustion space, ignites immediately, so that the ignition cannot even be said to be "slow." Similarly, once ignited, the combustion with the Diesel principle is certainly rapid and complete, so that nomenclature on these lines would be misleading. In this way engines working on the Diesel principle are suitably named "heavy-oil engines (Diesel system)," more briefly "Diesel oil-engines," and, in short, "Diesel engines." This last name has the great advantage of brevity, and is useful if, as will be explained, it has to be qualified in the case of certain exceptional engines. Again, the term, "Diesel generator set," as meaning a combined unit of a dynamo driven by a Diesel heavy-oil engine, is extremely convenient. Alternatively, "high-compression oil-engine" may be used if the term "high compression" signifies sufficient compression for igniting the injected fuel. Until such time as experience has consolidated the many types of engines now constructed into a few leading types, for which entirely new names will, no doubt, be required and found, these terms will probably continue in general use.

The most difficult engines to classify are those in which the main feature is the ignition of the fuel by the heat of compression, but which have some modification in the method of fuel injection. Examples of this type are solid-fuel injection engines, in which the usual air injection is dispensed with, or engines in which the fuel is injected at the commencement of the compression stroke at low pressure into a special fuel receptacle in the cylinder.

It may be mentioned that such engines do not readily, as a rule, burn the heaviest of fuel-oils, and so cannot correctly be called heavy-oil engines. They then require special names, qualifying those already given for the usual Diesel engines, such as "solid-fuel injection" or "low-pressure injection Diesel engine." The term "solid fuel injection" is misleading, as the fuel is, of course, liquid, and if the injection be other than that of a very finely divided spray, the combustion and running of the engine would suffer, so that "solid" is an extremely unhappy designation. As already explained, the foregoing term is taken to mean fuel injection without the aid of compressed air, and would really be much more suitably replaced by "airless fuel injection." There are already many distinct types of oil-engines on the market, and efforts to give separate names, and to create the impression of a discovery of something entirely new, because of some small modification apart from the main principle of ignition, are greatly to be deprecated.

Within recent years a great development has taken place in oil-engines of a type in which the fuel is injected into the cylinder without the aid of compressed air, and is caused to ignite by impinging on an incandescent surface. This is a development from the old hot-tube engine, as in the one case the hot tube causes the ignition of a gas, and in the other of the liquid sprayed to impinge thereon. Gradually these engines have been improved from the stage of burning paraffin and light oils to the capacity for burning heavy oils, with or without the aid of a fresh-water drip into the cylinder to enable sufficient power to be obtained without overheating. The compression pressures with these engines vary greatly according to the general design, and may be said, as a rule, to fall between 80 lb. and 250 lb. per sq. in., and in some of the most recent designs even considerably higher. Contrary to the method of Diesel-engine development, theory has played a very unimportant part in this progress. Theoretically, such engines are considered in text-books as "explosion-engines," similar to gas-engines. Whilst this is the case with certain types, yet improvements are rapidly being made towards more gradual ignition of the total charge, so that the term "explosion-engines" is ambiguous and generally somewhat erroneous. All internal-combustion engines under conditions of mal-adjustment are "explosion-engines." The engines in question work on both the four and the two-cycle principles. Supposedly on account of the compression pressures being a fraction of that required for the Diesel cycle, they are generally called "semi-Diesel engines," two or four-cycle as the case may be. This name is entirely misleading. The pressure of compression in this case is not a matter of primary importance. Another designation suggestive perhaps of slang—"the hot-bulb engine"—is very descriptive, almost visualising the engine, or at least its principal characteristic, and with the addition of the cycle, and the word "oil" becomes "the four or two-cycle hot-bulb oil-engine"—an excellent name.

With some of the latest engines of this type, the external hot bulb is almost lacking, yet the temperature of the compression alone is not relied upon to ignite the fuel, there being at least a slightly incandescent surface to ensure reliable ignition, while for starting up the usual blow-lamp is required. Engines of this type must then be classified as "hot-bulb engines."

A certain type of internal-combustion engine, in which heavy fuel oils are vaporised externally to the main cylinders, and the vapour is mixed with air and passed to the cylinders there to be ignited either by a hot bulb or an electric spark, come under the heading, to be exact, of gas-engines—*i.e.*, heavy-oil gas-engines, in which the hot bulb in this case is simply an ignition tube. The construction of such engines is, we believe, not being continued, so that they need not be further discussed.

We now pass to a consideration of petrol and paraffin-burning engines. These engines are virtually gas-engines, since the petrol and paraffin vapour generated in the carburettor or vaporiser is mixed with air and then passed to the engine cylinders, to be ignited electrically. Such engines are usually designated according to the fuel used, such as petrol, paraffin, alcohol engines, &c., but the type is generally known as the "petrol-engine." The classic anomaly of "cast-iron brasses" is called to memory by the phrase "petrol-engines burning benzol." Again, as has been seen with heavy-oil engines, the type of fuel is not a sufficient basis for classification, especially as developments in synthetic and mixed fuels and in types of internal-combustion engines are taking place so rapidly. For instance, suppose that a new fuel "X" be discovered, then "X engines" may not be sufficient to designate the type, but "X gas-engines" or "X hot-bulb engines" gives a clue to it. For this reason the insertion of the word "gas" is to be encouraged for engines in which the fuel is externally gasified or vaporised, mixed with air, and internally ignited and burned.

With engines of so many different types, developing separately, in works form erly, and in many cases still, producing all kinds of machinery, the names which have been assigned to parts common to the great majority of types of internal-combustion engines are various and diverse on account of the many influences at work. That such a condition is unnecessary is plain, and the disadvantages as leading to confusion are obvious, for it is possible to find several types of engines installed in one ship, or in one station, for which the Books of Instruction and the Spare Gear Lists are each differently worded. Looseness of nomenclature is always to be depreeated, and especially with complicated engines. As suggesting standardisation, the following notes may be of service :—

The first instance that might be taken is that of the engine framing, the term "framing" being understood to include the structure connecting the engine cylinders to the bed-plate. With high-speed engines, generally with forced lubrication and totally enclosed, the framing is more or less of box-shape, and is called the "crank-case" or "standard." Of these two terms "crank-case" is the better, as being more descriptive. "Framing" includes all other types, whether built up of columns and connecting girders, or of A frames, as with standard slow-running land Diesel engines in which the cylinder jacket is incorporated with the frame.

For the casting enclosing the end of the cylinder

and containing the valves, the terms "breech-end," "cylinder-cover," and "cylinder-head" are applied. The influence of gun nomenclature and with horizontal engines the similarity in appearance between the closed end of the cylinder and the breech end of a gun are responsible for the introduction of this term, although it does not redound to the credit of an internal-combustion engine if the comparison can be further drawn. With steam-engines "cover" is undoubtedly correct, but with internal-combustion engines the cooling-water spaces, the valves, &c., and the general complication of structure and functions make this part more than a simple cover, rather a "head." The top, or small end of the connecting-rod is connected to a pin driven into the piston, which pin is variously and equally well named the "piston" or "gudgeon-pin," although the latter has the advantage of more extended use. For the shaft driving the cylinder head valves the terms "cam-shaft," "eccentric shaft," "weigh-shaft," "half time," and "two to one shaft" are applied. The last two are only applicable to four-cycle engines, since with those working on the two-cycle principle this shaft has the same speed of revolution as the crank-shaft. The term "weigh-shaft" is borrowed from reversible steam-engines, but in the case under consideration its duties are so different that this name cannot be called suitable. There remain the terms "cam" and "eccentric shafts," according as the valves are actuated directly by cams or through links by eccentrics; and when the engine has more than one shaft of this nature, differentiation, such as "fuel cam-shaft" and "main cam-shaft" can well be applied.

Considerable confusion exists in regard to the terms applied to the valves in the cylinder-head. For example, the valve through which the fuel enters the main cylinder is variously called the Diesel, spray, fuel, fuel-injection, or injector-valve. "Diesel" and "spray valve" are not sufficiently descriptive; "fuel-valve" is confusing, as there are other ordinary valves in most engine-rooms controlling the supply of fuel, which can only be termed "fuel-valves." "Injector valve" is reminiscent again of steam practice, whilst "fuel-injection valve" can only mean that valve through which the fuel is injected (obviously into the main cylinder). When considering the pump supplying the fuel to this valve and the air for injecting the fuel into the cylinder, another advantage for this classification will be found.

The valve for the exhaust is always conveniently named the exhaust-valve or the cylinder exhaust-valve, to distinguish it from the ship's exhaust-valves, if any are fitted; but the similarly placed valve for admitting atmospheric air to the working cylinder is variously called the "inlet," "suction," "induction," or "air-valve," and of these suction is, perhaps, the simplest and best, whereas "air-valve," as being capable of confusion with the cylinder starting air-valve, is unsuitable. For this latter the term "starting air-valve," or "starting-valve," is good, and is differentiated from the engine-room valves by calling these latter "starting air stop and master-valves."

For the pump which supplies the fuel to the cylinder fuel-injection valves the term "fuel-pump" is insufficient, since many engines are provided with a simple pump for drawing fuel from the storage, and delivering it to the ready-use tanks. These latter are called "daily-service fuel-pumps," and the former the "fuel-injection pump." Similarly, the air for injecting the fuel into the cylinder for simplicity is called "fuel-injection air" or "injection air," preferably as retaining the term "injection" to either "pulverising" or "blast air." The correlated parts have in this way similar names—viz:—

Fuel-injection valves on cylinder-heads.
Fuel-injection pump.
Fuel-injection air, bottles, &c.

Compressors for supplying this high-pressure air are a necessary part of every standard Diesel engine, and are frequently of three stages. These stages can be named "first," "second," and "third stages," although, as being more definite, "L.P.," "I.P.," and "H.P." are certainly better. With steam-engines of more than three expansions, the terms "H.P.," "First I.P.," "Second I.P.," and "L.P." are used. The same system would not be suitable for four-stage compressors, since the course of the air is opposite to that of steam, and "H.P.," "Second I.P.," "First I.P.," and "L.P.," would give rise to confusion between the two middle stages. Thus "L.P.," "L.I.P.," "H.I.P.," and "H.P." would be more suitable.

With all four-stage compressors it has become standard practice to call the stages "1st," "2nd," "3rd," and "4th," but with Diesel compressors of three stages the better practice is to call the stages "L.P.," "I.P.," and "H.P."

For storing the air compressed by the engine compressor, containers are required; when the air is stored at above 500 lb. per sq. in., the form for convenience is that of a bottle or flask. Where the pressure of storage is below 300 lb. per sq. in., reservoirs of boiler form and construction are used. For the high-pressure air-storing vessels the term "bottle" is more generally used than "flask," and as being more specific, is better than "container," "holder," or "reservoir." A number of bottles constitutes a "group." For the low-pressure air "reservoir" is a very suitable term for the containing vessel.

To describe the water which is used with all internal-combustion engines (other than the smallest) to keep the temperatures of the parts subject to the combustion within reasonable limits, the term "cooling water" is all-sufficient, since its duty is to cool these parts. Sometimes "circulating water," as with steam-engines, is preferred, but in cases where steam and internal-combustion engine plants are working side by side, the differentiation consequent upon retaining the name "cooling water" in the case of the latter is an advantage.

Yet another branch of the subject is the classification of ships in which the main engines are of the internal-combustion type. Boats of limited, but not rigidly defined, size are by custom and usage called "motor-boats," whereas vessels of considerable displacement are designated as a derivative "motor-ship." The word "motor" by itself suggests an electric motor, but motor-cars, motoring, motor-boats, and motor-boating have given it quite another significance when used in this connection. We then get the term "M.S." as applied to ships so propelled, but this can be confused with "mail-ship" or "mail-steamer," so that, perhaps, the designation "M.V.," motor vessel, as being quite distinct, is preferable. This, then, is applied to all vessels propelled other than by steam-engines and turbines. There is, however, an example of propelling machinery in which Diesel engines drive generators, and these generators supply current to motors on the propeller-shafts. Steam-turbines and generators are also used in the same way. The first comes under the heading "motor-ship," but the second, no convenient name having been supplied, comes under steamship rating, although having electric motors, it might seem to be more correctly a motor-ship than those customarily so-called. With the increase in the number of tank-ships built, the term "oiler" is becoming more frequently applied to mean an "oil-tank ship," whether steam or Diesel-engined. The natural sequence is to adopt the names "motor-oiler" and "steam-oiler," with symbols M.O. and S.O. for convenience. This last branch of the subject, however, cannot yet be treated in a rigid manner, although it would certainly be desirable to standardise also in this respect.

To summarise, then, the foregoing conclusions:—

1. All engines in which the fuel is burned within the main cylinders to be called "internal-combustion engines."

2. Where the compression pressure is carried to an extent sufficient alone to ignite fuel injected into the cylinder, the type of engine can be designated "high-compression oil-engine," "Diesel oil-engine," or "Diesel engine," and when the density of fuel which can be satisfactorily consumed is greater than 0.90, "heavy-oil engine (Diesel system)" if desired can be used.

3. A combined unit of a Diesel oil-engine driving a dynamo is known as a "Diesel generator."

4. Engines embodying in the principle upon which they work the main condition No. 2, but with modifications in certain details of performance from the accepted standard Diesel engine, should retain the classification "Diesel," but, if desired, may be qualified by some term such as "low-pressure injection," "airless-fuel injection."

5. When liquid fuel is injected directly into the cylinder, but ignition and combustion are facilitated by means of an incandescent surface, the type to be known only as the "hot-bulb oil-engine," qualified, if desired, to indicate whether two or four-cycle, and to particularise the type of fuel burned.

6. All engines for which the fuel, as supplied, is gasified or vaporised and suitably mixed with the air to support combustion, externally to the engine itself, and which for the ignition of this combustible mixture in the main cylinder an electric spark (now almost universal) is employed, are gas-engines.

7. Classification of gas-engines according to the nature of the gas used is the only convenient way, but the inclusion of the word "gas" is desirable—viz.:—

Coal-gas engines (not coal engines).
Alcohol-gas engines.
Petrol-gas engines.
Paraffin-gas engines, &c.

8. Suitable names for the various parts common to most internal-combustion engines are as follow:

Engine framing, engine crank-case.
Cylinder head.
Gudgeon or piston-pin.
Cam or eccentric shaft.
Fuel-injection valve, pump and fuel-injection air bottles.
Daily service fuel pump.
Suction-valve and exhaust-valve.
Starting air-valve or starting-valve.
Starting-air stop or master-valves.
Compressor stages: low-pressure, intermediate-pressure, and high-pressure.
Group of starting-air bottles (high-pressure air).
Starting-air reservoir (low-pressure air).
Cooling-water.

The German Steel Union in 1915.—A shortage of about 50 per cent., as compared with the last normal year, represents the result of 1915 for the German Steel Union as regards the quantity of goods despatched, and the shrinkage applies to all kinds of goods, although to a varying degree. The quantity despatched during December showed some slight improvement as against November, but was below the figure of December, 1914. The actual quantities despatched were:—December, 1915, 264,270 tons; November, 1915, 241,750; December, 1914, 268,189 tons, which again represent 49.23 per cent., 44.91 per cent., and 51 per cent. of the allotment respectively. The total quantity despatched during 1915 is some 30 per cent. smaller than that of 1914, and, as already mentioned, some 50 per cent. short of the last year of peace. The quantities despatched during the last three years of half-finished goods, railway material, and shaped iron were as under:—

	Half-finished goods. tons	Railway material. tons	Shaped iron. tons
1913	1,686,692	2,879,742	1,778,307
1914	1,141,480	2,190,671	1,401,818
1915	825,489	1,623,884	856,722

Compared with the preceding year, the decrease for 1915 consequently amounts to about 316,000 tons for half-finished goods, to about 567,000 tons for railway material, and about 545,000 tons for shaped iron. The following table shows the fluctuations in the three different sections of goods during the last nine years:—

	Half-Finished Goods. tons	Railway Material. tons	Shaped Iron. tons	Total. tons
1907 ..	1,558,000	2,327,000	1,699,000	5,584,000
1908 ..	1,891,000	2,071,000	1,803,000	4,765,000
1909 ..	1,508,000	1,947,000	1,615,000	4,970,000
1910 ..	1,624,000	1,878,000	1,805,000	5,307,000
1911 ..	1,744,000	2,087,000	1,983,000	5,814,000
1912 ..	1,918,000	3,347,000	2,171,000	7,436,000
1913 ..	1,681,000	2,880,000	1,778,000	6,339,000
1914 ..	1,141,000	2,191,000	1,402,000	4,734,000
1915 ..	825,000	1,624,000	857,000	3,306,000

German Cement Industry.—As might be expected, the war has had a very unfavourable effect upon the German cement industry, which, so far as a good many works were concerned, was by no means too flourishing before. Strenuous efforts had for some time been made to gather all the German cement works into one fold—in an All-Germany Cement Kartel—but persons taking a sober and unbiassed view of these endeavours were very sceptical as to the feasibility of the scheme. One great obstacle was the divergent interests of the sundry existing cement unions in different parts of the country. The result of the negotiations is the complete abandonment of the plan, which proved as futile as one or two previous attempts to control and consolidate, to some extent, the German cement industry, and no further attempts are in the near future likely to be undertaken in this direction. The badness of the times in the cement industry is illustrated by the Teutonia Misburg Portland Cement Works. Differing from nearly all other German cement companies in raising its dividend for 1914 from 8½ to 10 per cent., the year 1915 has proved so bad that no dividend will be paid. There certainly was a surplus in the first six months of last year, but it was absorbed by losses during the second. Apart from the general precarious position of the cement industry, the position has further deteriorated from shortage of labour and insufficient coal supply. The cost of production has increased, and there is no prospect of a rise in the quotations.

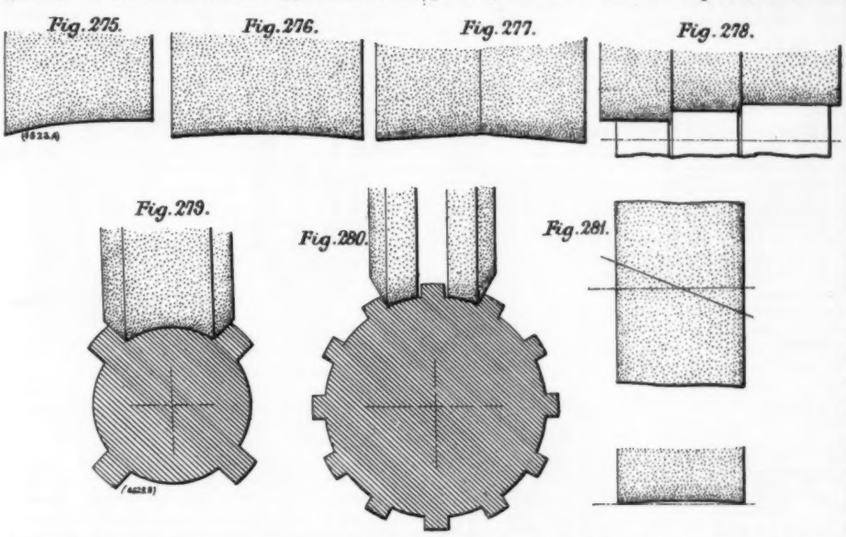
GRINDING-MACHINES.—No. XIX.

By JOSEPH HORNER.

THE profile branch of form-grinding is one of recent growth. The grinding of irregular profiles was illustrated in ENGINEERING for April 3, 1903, page 440, and October 28, 1904, page 566, but in those examples the grinding-wheel was traversed under the control of a form or templet. The method on which present attention is being concentrated is that of grinding with a wheel, straight or profiled, which is not traversed at all, but is only fed on to the surface of the work. The first successful utilisation of this method on an extensive scale was that of grinding the pins of multiple-throw crank-shafts, which has been already illustrated in this series (see ENGINEERING, February 26, 1915, page 237). In this case the reason why the feeding-in movement is adopted is that the length of traverse, ranging only from, say, 2 in. to 4 in., is short, and for a good while the crank-pins were either turned only, or rough-turned and finish-ground. Now they are often ground entirely from the rough forgings with much economy in time. But the method now appears to be on the eve of a greater development. Recently a new machine—the Ford-Smith—has been introduced for grinding the whole length of a shrapnel-shell case, including the ogival nose, by a feeding-in motion. Much more work of the same class will doubtless be done when conditions become favourable to the practice. These are the re-designing of machines on stronger lines, provision for re-truing the wheel in its place, and a proper regulation of speeds and feeds. We may glance at each of these for a few moments.

The necessity for re-designing machines scarcely needs an argument. Yet an effort is required to break away from old prejudices that were born of the time when grinding-machine practice was modelled on that of the lathe. We are witnessing now, in addition to the growth just named, that of the broad-form wheel fed inwards, the employment of wide wheels for traverse work, with a length of traverse across nearly the whole width of the wide wheel during a single revolution of the work. These combinations would not have been entertained a short time since. All wheels, until recently, were narrow, and the traverse was considerably less than their width. Only thus, it was believed, could accurate results be secured. And the employment of wheels of the full width of the work, and used without traverse, is, perhaps, the more important of the two. This growth is very closely allied to that which has occurred in milling-machine practice. First, narrow cutters, not exceeding an inch or two in width, were used in light machines. Then followed the employment of wider mills, either solid or built up in gangs, the full utilities of which were hampered by the weakness of the then-existing machines, that were not built for the more strenuous duties thus imposed on them. Afterwards, when machines were remodelled, the gang-milling became established practice. Precisely the same kind of movement is now going on in the grinding-machines, in order to enable them to deal with broad cutting. Such machines have to be built rigidly, in their framings, sliding portions, and spindles, on similar lines to some of the recent machines which have been illustrated in this series. What it means is, that instead of using wheels of only an inch or two wide, wheels are regularly employed now 4 in. or 5 in. in width, and in some instances they range up to 10 in. in width. In plain cylindrical grinding, the resulting economy is directly as the width of face of the wheel. A wheel 6 in. wide should perform six times as much work as one 1 in. wide. Against this has to be set the fact that more frequent re-truing is necessary.

The advantage which does undoubtedly arise from the employment of a traversing-wheel is that it is largely self-corrective. It embodies a principle similar to that possessed by the turning-tool when traversing in a lathe—a narrow edge which produces a spiral cut. The similarly traversed wheel retains its outline for a long period, being reduced in diameter chiefly. But when a wheel is fed inwards instead of being traversed, it quickly loses its accuracy, whether plain or profiled, and its errors are reproduced at once on the work, and therefore frequent re-truing with a diamond becomes necessary. But the question at once arises whether the time that is saved by using a wide non-traversing wheel is or is not discounted by the necessity of frequent re-truing. It may be too early to express dogmatic opinions, but the fact must be accepted that the movement is growing, and the number of pieces which can be ground after each re-truing of the wheel is not so small as one might anticipate. It depends chiefly on the size of the work. On pieces of large diameter a dozen only may be ground for each re-truing of the wheel, but on small shafts from 75 to 100. And, further, it may be claimed that more accurate results are secured when repetitive and interchangeable work are concerned by adopting wide form-grinding than by using narrow traversing-wheels. In the latter, the wear of the wheel and of the slides may result in slight deviations from perfect parallelism and uniformity in dimensions. The form-wheel is fed in until the end of the cut, where it is allowed to "dwell" until sparking ceases. Grinding can, it is said, be done in this way to limits of 0.0005 in. The feeding-in is performed either by hand or by self-acting mechanism. The latter is to be preferred, since less skill is demanded of the operator. In a Brown and Sharpe arrangement the feed is derived from an eccentric fitting on the spindle of the work-head. Thence, through various levers, a pawl is made to actuate a feeding-dial with ratchet teeth. Passing two teeth feeds the wheel in at the rate of 0.002 in. per revolution of the work until the correct diameter has been reached, when the feed is automatically thrown out, after which the wheel "dwells" until no more sparking occurs. Form-wheels are of simple shapes. Many are just ordinary wide, straight-faced wheels, not traversed. Others have simple curves, as shown in Figs. 275 and 276, or combinations of curved and straight edges, or of straight edges set in angular relations, as shown in Fig. 277.



In this class of grinding, slow surface speeds are adopted for the work, and these may range only from 30 ft. to 55 ft. per minute. Soft wheels are preferred to hard ones, and those, also, of coarse rather than fine grain, as being less liable to glaze. Combination wheels are commonly used for the alloy steels. The wheels are run at from 5500 ft. to 6500 ft. per minute surface speed.

As cylindrical form-grinding was first adopted on a commercial scale for the crank-shafts of automobile work, so its extension is being rapidly developed in connection with other parts of these vehicles, especially for dealing with axles and shafts of various kinds. It shows to advantage on shouldered or stepped shafts which have several diameters. These again are produced most economically by dividing the work amongst different machines, employing a separate machine for each step, with its own setting; but this, of course, presupposes a large output. But sometimes the wheel is shouldered, provided the differences in diameters are not large. An example of this is illustrated in Fig. 278.

Another kind of form-grinding is that in which a wheel is ground to a sectional shape and traversed. An example of a section formed in this way occurs in the splined shafts used for gear transmissions, in which the splines or keys are solid with the shaft. Figs. 279 and 280 show sections of such shafts with the grinding-wheels used in forming them. The amount removed at the final grinding is small, only about 0.002 in., the shafts being rough-ground first, and the wheels being re-trued very frequently.

Re-truing a wheel in place is done by means of attachments which are permanent fittings of the machine. They vary with the profile of the wheel. The plain mountings fitted now on many tailstocks are used for the narrower wheels. For wider wheels the attachment embodies either the "radial" method or the "form" method, the first being for regular curves, the second for any irregular outlines. The radial method is used for radii up to about 12 in. In this the diamond is swung about a pivot which occupies the centre of the curve. The radial position of the diamond may be varied in some instances, but in others it is fixed at one radius. This method is employed chiefly for small radii, such as the fillets on crank-shafts, roll-necks, and so on. The same kind of attachment is used for turning the straight portion of a wheel by simply locking the swing-frame in a suitable position. The truing member is attached permanently to the footstock, so that the work need not be removed from the centres; or in another design it is set on the table, in which case the work must be taken out in order to true the wheel. The formed outlines of the wheels are produced directly from copies or master-forms of similar outlines, which are made to control the movements of the diamond across the face of the wheel. Any profiles can be produced in this way. The only limitation which occurs is that of depth, because any great variations in the diameters of adjacent parts has an influence on the surface speeds, and along with these the grain and the grade of the wheel, and, consequently, the cutting actions. Neither can there be any keen angles, nor very weak sections, nor under-cutting.

A special adaptation of form-grinding is that of crowning pulleys with a uniform radius, in preference to employing two tapers. The wheel face is trued to the concave profile by tilting the carriage which carries the diamond at an angle, as shown in Fig. 281, and so traversing it diagonally across the face of the wheel. Since the diamond cuts more deeply about the centre of the wheel than at the edges, the result is that a regular curve is imparted to the wheel face.

While these articles are being written, other new applications of grinding are being made, one being finishing the outsides of shell-cases, the other finishing rifle-barrels. In both instances turning is either dispensed with, or it is relegated to the roughing operations only. The work on the rifle-barrel is done by a wide wheel, but traversed; that on shells by the form-grinding just described, the wheel or wheels being fed into the surface. The grinding of the rifle-barrels follows the reaming of the bores and the straightening of the barrels. They are supported against steady-rests. A wheel of about 2-in. face is used. Light cuts are taken, and the traverse nearly equals the width of the wheel per revolution. But details of the particular

methods employed vary with the longitudinal outlines of the barrels, chiefly consisting of differences in tapers, so that the barrel is ground in sectional lengths on different machines. As the barrels are long and slender, local heating has to be avoided if distortion is to be prevented. This is one reason why broad traverses are taken, and also why the work is rotated at a high speed, so distributing the heat as quickly as possible. Also a very ample supply of lubricant is poured over the wheel. As set up for grinding in the Churchill machines a surface speed of about 80 ft. per minute is given to the work, and a barrel is ground in from three to four minutes. A free-cutting wheel is used, which is re-trued once in a day. In another Churchill machine the wheel is controlled by a former fixed on the bed.

This and the preceding articles of the present series have been written with the object of illustrating, in a reasonably comprehensive way, the developments which have taken place in grinding-machines since the publication of a previous series twelve years ago.* But a number of cardinal matters of detail remain undiscussed, and these it is proposed to illustrate in the three or four concluding articles of this series. These details include the designs of wheel-heads, and the safety of wheels, the work headstocks and footstocks, the steadies, and the feeding arrangements.

In the previous series in ENGINEERING on "Grinding-Machines and Processes," the principal elements were dealt with from this aspect (ENGINEERING, June 12 and 26, July 10 and 24, August 7 and 21, 1903). The articles following may be regarded as supplementary to those just named, and as recording advances which have been made during the last twelve years.

In no machine-tools are the conditions which are imposed by high speeds and by the exceedingly minute limits in results so severe as in the grinding-machines. The peripheral speeds are as high, often higher, than those of an express train. Yet the limits are measured in fractions of a thousandth part of an inch, or less than the thickness of a human hair or of the finest tissue paper. The two most destructive agents to be combated are vibration and wear. The slow and cautious evolution of the grinding-machines has been characterised by the gradual elimination or the correction of these evils. By devious paths and varied designs different manufacturers have succeeded in achieving like results; yet, if regarded from some aspects, similarities are more common than differences. On the other hand, the practice of any single firm points unmistakably to the evolutionary character of the improvements that have been made slowly and tentatively. Only when examples of the earliest and the latest practice are compared do the differences strike one as being of a radical character.

The three features which characterise all the best grinding-machines to-day are: rigidity, which is necessary to withstand and absorb vibration; handiness to facilitate the operations done; and the preservation of durability by reducing and correcting the effects of wear.

Rigidity is secured partly by the massing of metal, as in head castings, in spindles, in beds, and so forth. But of equal importance is the judicious disposition of the metal. The more valuable it is the more reason is there why it must be economised, whether it be selected cast iron, bronze, or tool-steel. And the necessity becomes the more insistent with the present enormous growth in dimensions, and with the heavier duty which is demanded of the manufacturing machines. Vibration can be checked when it arises from unsuitable speeds and some other minor causes which are familiar to grinding operators. But if it is inherent in the bad design of the machine, it cannot be avoided, and then the most efficient speeds and feeds cannot be utilised. Machines should also properly be designed for carrying the heaviest wheels, the highest speeds, and the coarsest feeds that are ever likely to be used on them.

The beds perhaps afford the best illustrations of distribution of metal to ensure rigidity. The metal is never thick, regarded relatively to the dimensions of the casting. But it is disposed in girder-like fashion, is frequently of boxed section, being plated at top and bottom, and the sides are tied with cross-ribs. The utilitarian aspect is happily linked with the rigid design, since water-tanks and drainage systems are combined with the plating and the ribbing. The base castings are therefore often rather complicated examples of coring. In some recent designs the ways are chilled, which is liable to put some strain on a lightly proportioned casting, and this, in addition to the pull exercised on the sides by the shrinkages of ribs and webs.

The bed or base is usually cast in one piece to include the ways for the traversing element, this being either the work-table or the wheel-head, and those for the fixed element. In each case the vertical ribs are located directly beneath the ways and go down to the floor. The property of rigidity is also one of vital importance when regarded from another aspect than that of rigidity merely. It embraces the alignment of the head and the footstock, and of the axis of the grinding-wheel. The elimination of spring or wind is as essential as the original accuracy of the ways, because spring and wind will spoil the alignment, on which the accuracy of traverse grinding depends. A quarter of a thousandth of an inch or less of wind will suffice to neutralise the limit of error allowed. It is to avoid this that many machine-bases have a three-point support.

The ways now in use are crystallised pretty generally in the form of a flat and a V, by which alignment is more readily preserved than with two V's, or two flats, with gibs. The reason why the double V's used on planers are not adopted in grinders is, that the pressure of the first occurs along the plane of the V's, that of the second transversely to them. And any inequality of wear that may occur on one side, consequent on lateral pressure, does not matter, because the flat face slides laterally.

Handiness, in order to facilitate operations, is the reason why all hand-wheels, levers, and stops are located at the front of a machine. This entails much careful arrangement in a complicated machine of large dimensions. Each movement of traverse and cross-feed and reverse is controlled both by hand and automatically. Work-speeds and table-speeds are changed, steadies are arranged, footstocks secured, tables are swivelled, stops set, water-supply controlled, and all within an area of 2 sq. ft. to 3 sq. ft. in front of the attendant. Compactness is thus secured, and is carried further by the adoption of the single belt-drive to a constant-speed pulley, or to a constant-speed drum (suitable in cases when the wheel-head traverses) or to the motor drive.

In the first of these cases the countershaft is reduced to a simple element, and a multiplicity of belts is dispensed with. In the last case the motor drives directly, or it may drive through one belt to a single pulley. The full significance of these vital changes may be realised by comparing the machines described in ENGINEERING twelve years ago (see, for examples, the issues of September 4 and 18, 1903) with those illustrated in some articles of the present series. The new system involves the employment of nests of gears which were absent from the older machines, but the high degree of excellence now attained in the manufacture and mountings of these gears practically removes all objections to their use. The gears are invariably enclosed in boxes and within the framings, and are operated by fool proof devices. And again, in some designs, belt-drives are retained for changing work-speeds and traverses, though the main drive is from a single shaft. Levers outside the bed shift the belts to the various steps of the cone pulleys.

Mechanically beautiful in the best machines are the numerous and varied provisions which are introduced for preserving the pristine accuracy of the machine fittings. These include such distinct items as the selection of metals, the dimensions of wearing surfaces, methods of take-up, and systems of lubrication. Each is contributory to the permanent efficiency of the machine.

The careful selection of metal is necessary for all parts, from the cast iron in the base to the bearing metals, and the material for the gears.

Fig. 282.

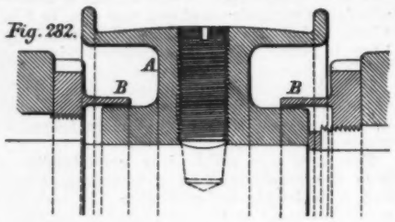


Fig. 283.

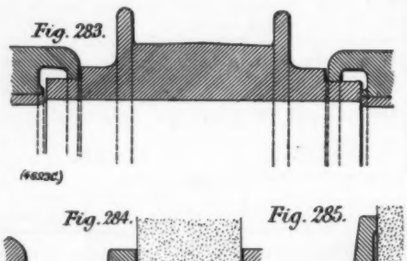


Fig. 284.

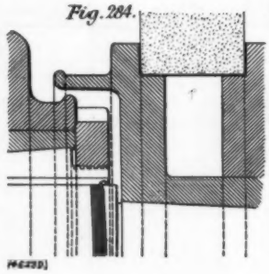


Fig. 285.

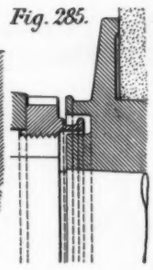


Fig. 286.

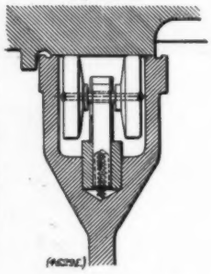


Fig. 287.

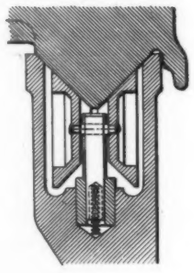


Fig. 288.

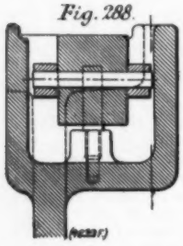


Fig. 289.

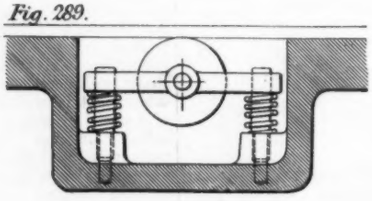


Fig. 290.

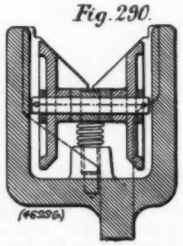
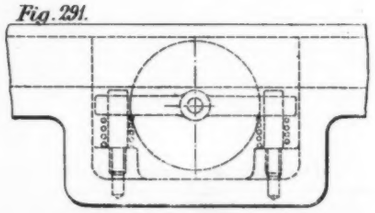


Fig. 291.



* "Grinding-Machines and Processes," and "Tool-Grinding Machines." ENGINEERING, vols. lxxiv. to lxxviii.

Cast iron must be tough without being hard, a grade which will not "draw" in cooling, or be brittle. Bronze for bearings is either good gun-metal or phosphor-bronze, and sometimes Babbitt or other white-metal alloy. Spindles are of a tool-steel, hardened gears are of tough steel, often of chrome-nickel steel, heat-treated.

The dimensions of wearing surfaces still tend to increase, though they are now so large that wear is delayed almost indefinitely. This applies to the sliding surfaces of tables and wheel-heads, and to the journals and bearings of spindles, both in their diameters and lengths. In many machines a difference is made in the dimensions of the front and hinder journal-bearings of the work-head. Ample length is given to the sliding surfaces, not alone to keep the ways covered, but also in order to lessen the friction and wear per unit of surface.

The methods of take-up are various and numerous in regard to their details, and provide for the most minute corrections. The movement of a screw is utilised, and scraping is done where that is suitable. With the adoption of more liberal proportions, the need for take-up to correct wear lessens, and wear is further delayed by the very ample protection which is given to parts that are especially subject to the entrance of grinding dust. Figs. 282 to 285 illustrate the general methods of making one element of the machine afford protection to another adjacent. In Fig. 282 the bosses of the pulley A are well covered by annular extensions of the nuts B, B, by the turning of which, wear of the tapered bearings is taken up. In Fig. 283 the extensions of the pulley-bosses not only afford protection to the bearings, but prevent the oil from being thrown out by centrifugal force. In Fig. 284 the wheel-plate has an annular extension, which covers over the front end of the front bearing, and prevents the oil from coming out, while the take-up nut closes the end of the bearing. In Fig. 285 the nut itself is provided with an annular extension, which is embraced and covered by a similar extension on the wheel-boss.

Lubrication, too, is so ample that metal need never run in absolute contact with metal. The slides are provided with rollers in pockets, which throw up the oil from the pockets. Methods of lubricating slides are shown in Figs. 286 to 291. Fig. 286 comprises two spring-pressed plain rollers for flat slides. Fig. 287 shows two for V'd slides. In Figs. 288 and 289 a single wide roller is used, mounted at the centre of a spring-controlled compensating lever. In Figs. 290 and 291 the same method of mounting is shown for bevelled rollers for V'd slides. Generally the edges of the sliding table cover the edges of the ways on which it moves.

Spindles are lubricated from an oil-supply contained in their boxes, with contact ensured by felt pads and the cutting of right and left-handed oil-grooves. Examples will be seen in the next article of this series. The ends are protected from entrance of grinding-dust by the overlapping of nuts, flanges, pulley-bosses, or of tubes. Mechanisms that lie within the machine-base are oiled through tubes, the entrances to which are closed with screws, or they might be supplied by gravity from a reservoir.

Another, and a radical, difference which one observes when comparing the machines of only a dozen years ago with those of the present is the separation of the feed mechanism from that of the speed movements. The change to independent feeds was beginning then, but it has been accomplished now, and is embodied in every good design. What this change means in efficiency of output hardly needs much explanation. When only three or four table feeds were available for each speed of the work, it continually happened that either one or the other was not the best for some piece of work in hand. Coarse feeds could not be got with slow work speeds, and fine feeds were often employed when coarse ones would have been better. The fault lay in the fact that feeds were derived from, and depended on, speeds. Now very coarse feeds are frequently combined with rapid work speeds, with correspondingly high output, because the two kinds of movements are derived from separate and independent sets of gears or belts.

There is little to be added to the subject of travelling heads *versus* travelling tables, discussed and illustrated in ENGINEERING of August 7, 1903. Both systems are retained, and the methods of construction show no substantial change. Only, because machines have grown to such large dimensions, it has become inevitable that some special care must needs be taken in dealing with the more massive moving parts, which is rendered even still more necessary because finer, more precise results are demanded of grinding-machines than was the case a dozen years ago. Firms who are committed to either design retain it, and maintain the advantages which they claim it possesses over the other. But the disadvantages which lurk in either design are minimised by the excellence of the details. Still one may hazard the opinion that with the great increases made in the dimensions and length of traverse, the fixed wheel-head has advantages over the travelling head. It is better for the operator, who has the wheel constantly under observation; better for the stability of the head itself; better, too, for the maintenance of the truth of the traverse-ways, which do not wear so irregularly when a work-table travels over them as when a wheel-head does. The first covers the ways nearly always, the second does not; consequently the wear is located over a smaller area than in the first case. It is the problem of the localisation of the wear caused by a slide-rest on a long lathe-bed when used frequently for face-plate work. With heavier wheels, and the more severe duty demanded of manufacturing machines, the mass of the wheel-heads and of the work-tables is increased to secure the necessary freedom from vibration. But added weight entails more care in designing the mechanism of travel and reverse, with absorption of shocks.

The protection of slides and spindles is also more imperative because of the increased rate at which grinding is performed. If done dry, there is a larger quantity of dust thrown off, much of which is liable to be drawn into the moving parts. If wet, a much larger volume of water flows in the vicinity of vital parts. These features are reflected in many interesting details in the designs.

The mechanisms for driving and reversing moving tables are in essentials those which have been embodied in nearly all machines from their first inception, comprising the nest of reversing bevel-gears actuated from the trip-lever, when struck by the table-dogs. In addition, there is included mechanism for imparting a sharp impulse to the clutch, without which the slowly-moving table might be liable to come to a standstill instead of reversing. In connection with this there is the device, universal now, for permitting the work-table to be moved beyond the point of reversal without disturbing the clamping of the trip-dogs.

THE DRY BLAST IN THE MANUFACTURE OF IRON AND STEEL

THE subject of the desiccation of air for blast-furnaces seems to deserve a little more attention than it has lately succeeded in attracting. Much water has flowed under the bridges since Mr. Gayley first made public the results of his Pittsburg experiments, and, in the interim, it must be confessed that the enthusiasm which his figures aroused has, so far as this country is concerned, given place to apathy. But whether this attitude is, or is not, fully justified forms a question which is at any rate worth the asking.

Investigation shows that at least five plants have been installed in Great Britain, and that most of these are not considered to yield a sufficient return for the outlay involved, while two plants which were put up in Germany were shut down after twelve months' running. On the other hand, the installation at the works of Messrs. Guest, Keen and Nettlefolds, Cardiff, showed, as already stated in ENGINEERING,* a saving in fuel of 13.4 to 18.4 per cent., and an increase in output of 14.1 to 26.4 per cent.; and, so far as can be ascertained, most of the American plants have effected notable economies, varying from 10 per cent. saving in fuel and 12 per cent. increase in output, up to 20 per cent. saving and 20 per cent. increase.

The explanation of these divergent results is to be found either in the variation of local conditions or in differences of practice. Examples of the former are: the quality of the air, fuel, and product; and the nature of the climate; examples of the latter are the pressure and the temperature of the blast, and the burden put upon the fuel. The theoretical economy in fuel to be expected with dry blast may, in fact, for different conditions, vary from 6 per cent. up to 34 per cent., if the calculations published by Professor Ehrenwerth* are correct. And since, at one time, the cost of a plant for a furnace turning out some 1200 tons of pig per week was as high as 25,000*l.*, it is clear that only in the more favourable circumstances could a substantial return on outlay be expected. If, however, the prime cost of the plant could be reduced, and the cost of operating it be lessened, then the radius within which it would pay to make the installation must be proportionately increased. One or two improvements in design have been made which tend in this direction, and it is these that it is now proposed to consider. At the same time an account will be given of the lesser known application of the dry blast to steel-making, a process which it is thought may indirectly have the same effect.

It may be worth while, in the first place, to recapitulate the chief advantages claimed for the dry blast, as produced by the agency of refrigeration.

The desiccation of the blast by calcium chloride, which is the only alternative that has been put forward, has already been fully described;† but while the initial cost of a plant on this system would appear to be very much less than the cost of an equivalent refrigerating plant, it is probable that the running costs would be much higher. It is stated that in the calcium chloride system the expenditure of 7500 calories on regenerating the chloride from its hydrates is necessary per kilogramme of water deposited. With refrigerating plant not more than 1200 calories per kilogramme of water are required, and this amount of refrigeration would be produced by the expenditure of some 300 calories in the cylinders of the engines driving the compressors; and, although the regeneration of the calcium chloride can be effected by waste gases from boilers and hot-blast stoves, the refrigerating plant saves more than the power it consumes by the reduction, on account of the denser air supplied, in the power necessary for the blowing-engines.

In actual practice refrigeration is the system almost universally used. The benefits which its employment produces were first discovered, as is well known, by Mr. Gayley, and were made public by him before the Iron and Steel Institute eleven years ago.‡ He found that, in the months of August and September, the application of the dry blast at the Etna furnaces, Pittsburg, increased the output of one furnace from 358 to 447 tons of iron per day, and decreased the coke consumption from 2147 lb. to 1726 lb. per ton of iron produced. The revolutions of the blowing-engines were decreased from 114 to 96 per minute, diminishing the blast from 40,000 cub. ft. to 34,000 cub. ft. of air per minute, and reducing the power taken by the engines from 2700 to 2013 indicated horse-power. This saving gave enough power to drive the refrigerating compressors, since these took only 535 indicated horse-power. At the same time the temperature of the blast was increased, and the temperature of the waste gases reduced from 538 deg. to 376 deg. Fahr. The analysis of the waste gas showed:—Normal blast, CO 22.3 per cent., CO_2 13 per cent.; dry blast, CO 19.9 per cent., CO_2 16 per cent.; and the burden was increased from 20,000 lb. of ore and 5000 lb. of limestone on 10,000 lb. of coke, up to 24,000 lb. of ore and 6000 lb. of limestone on 10,200 lb. of coke. Ores were used giving an average of about 53.5 per cent. of iron, and the product was basic pig containing less than 1 per cent. of silicon. Later experiments in the winter confirmed these figures, although, as was to be expected, the increase in output was not so high. The saving in fuel, on the other hand, remained approximately the same.

During the August experiments the humidity of the blast was reduced from an average of 6½ grains to an average of 1½ grains of water per cubic foot of air, corresponding to a condensation of some 4100 gallons per twenty-four hours. But large as this quantity of water is, the saving of the heat, which would otherwise be required for its dissociation, accounts for only a small part of the actual economy in fuel. The remainder is due principally to the reduction in temperature of the waste gases, and the greater efficiency of the reducing gases, indicated by the increase in percentage of carbon dioxide. This improved combustion of the fuel in

* See ENGINEERING, May 2, 1913, page 612.

* See ENGINEERING, May 2, 1913, page 612.

† *Ibid.*, May 12, 1911, page 632.

‡ *Ibid.*, November 11, 1904, pages 656 and 661, and May 26, 1905, pages 665 and 668.

TWO-STAGE AIR REFRIGERATING PLANT AT THE WORKS OF THE STEEL COMPANY OF CANADA.

CONSTRUCTED BY MESSRS. FRANK C. ROBERTS AND CO., ENGINEERS, PHILADELPHIA, U.S.A.

SECTION OF REFRIGERATING AND CONDENSER HOUSE

Fig. 1.

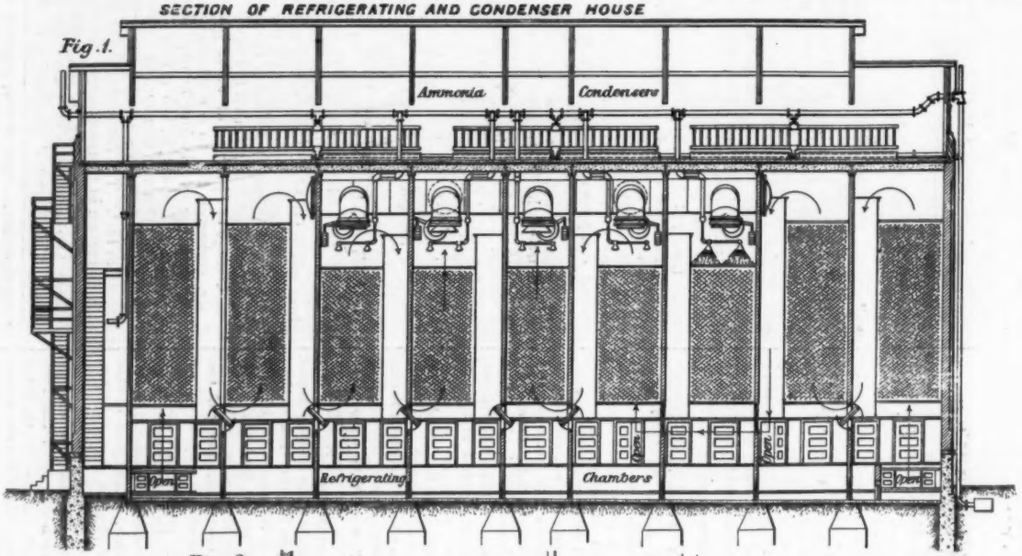


Fig. 2.

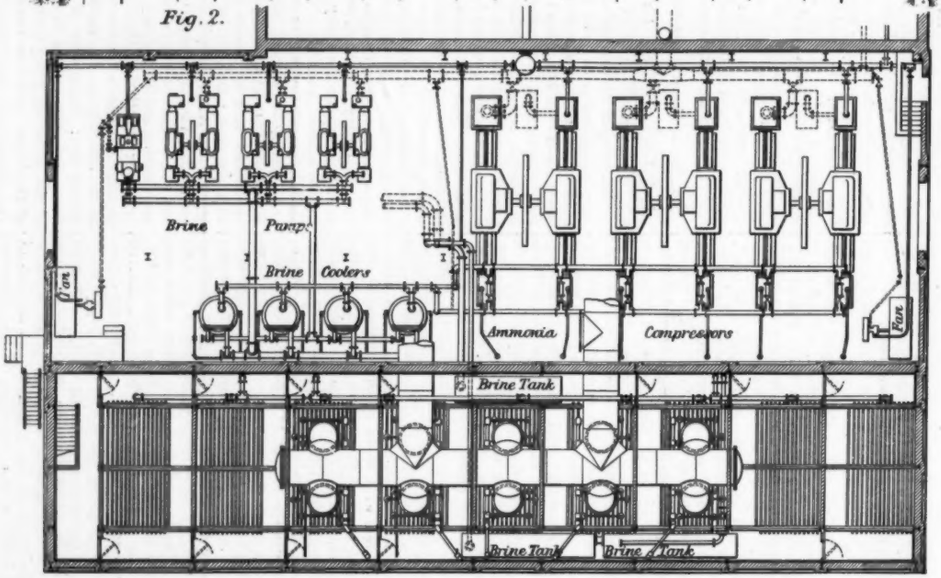
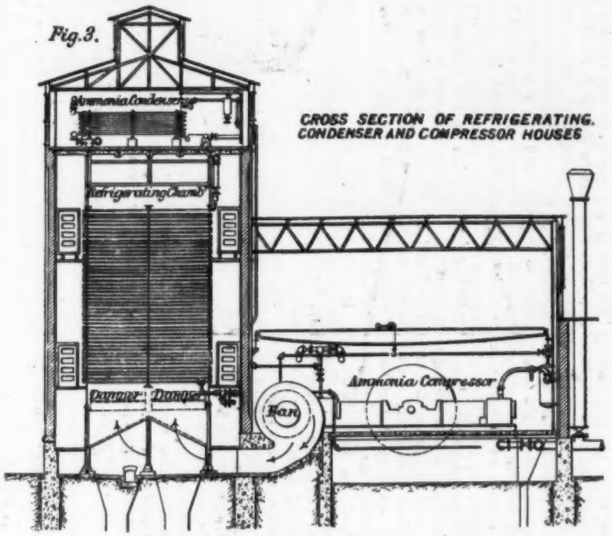
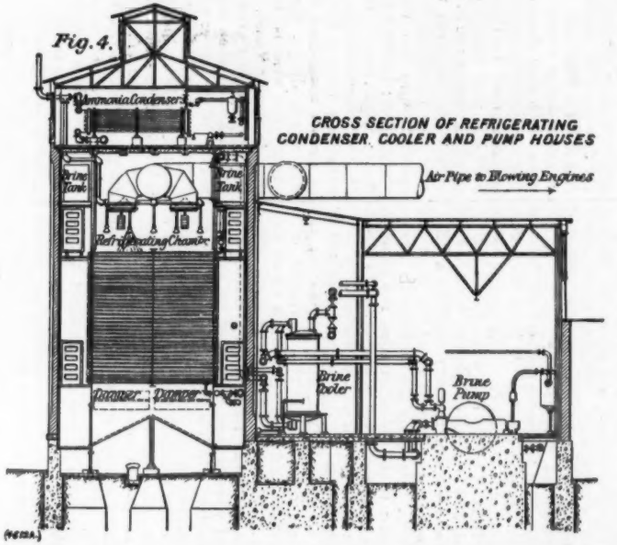


Fig. 3.



CROSS SECTION OF REFRIGERATING, CONDENSER AND COMPRESSOR HOUSES

Fig. 4.



CROSS SECTION OF REFRIGERATING CONDENSER, COOLER AND PUMP HOUSES

turn reacts on the loss in the waste gases, since it means that less fuel is being used and less blast, so that a smaller weight of gases is being formed. The importance of efficient combustion will be appreciated when it is remembered that, of the total heat of combustion of carbon—viz., 14,000 B.Th.U. per lb.—10,000 are liberated at the conversion of carbon monoxide into carbonic anhydride, and only 4000 at the formation of the monoxide itself.

Other causes contributing to the total economy are the increase in temperature of the blast, the smaller amount of slag to be melted, corresponding to the reduction in fuel consumption, and the saving in ore dust lost at the furnace top. With fine ores, where the loss has been known to amount

TWO-STAGE AIR REFRIGERATING PLANT FOR DRY BLAST.

CONSTRUCTED BY MESSRS. L. STERNE AND CO., LIMITED, ENGINEERS, GLASGOW.

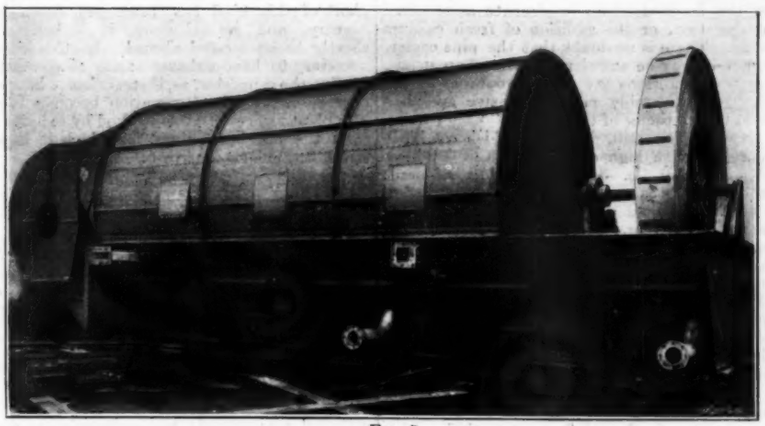


FIG. 5.

Fig. 6.

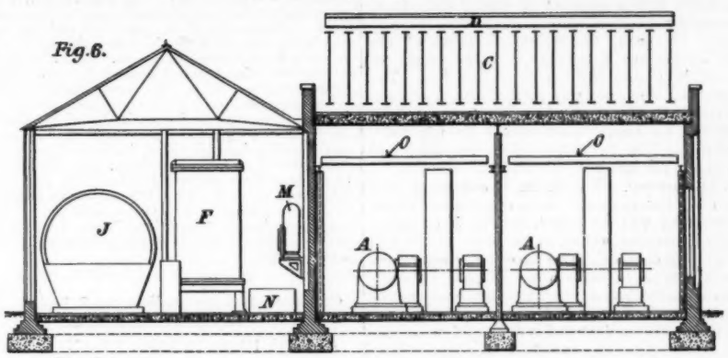
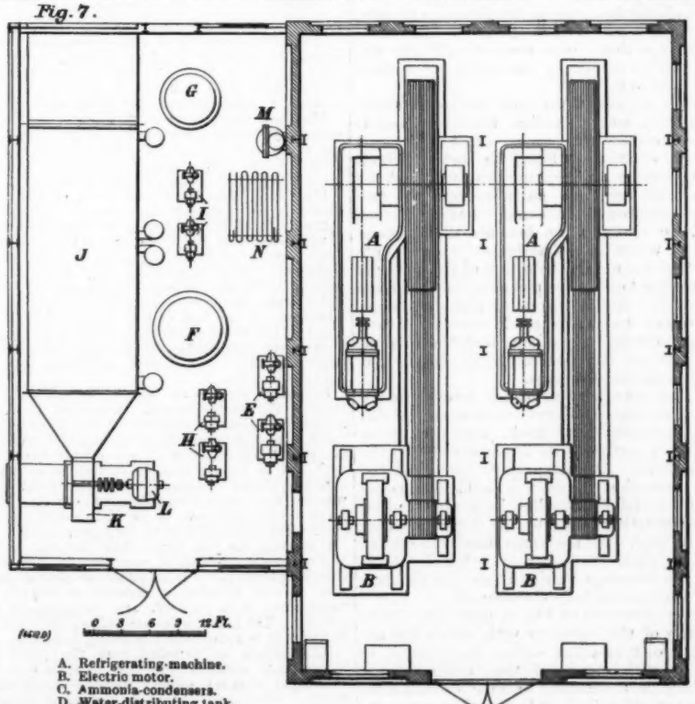
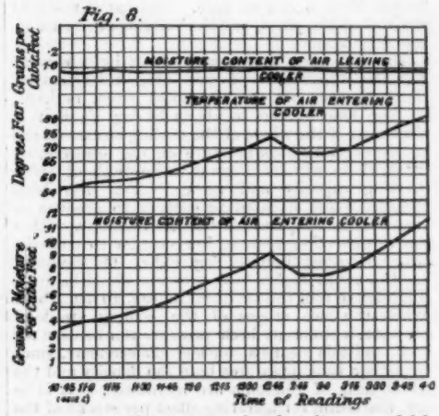


Fig. 7.



A. Refrigerating-machine.
B. Electric motor.
C. Ammonia-condensers.
D. Water-distributing tank.
E. Condensing-water pump.
F. Shell water-cooler.
G. Shell brine-cooler.
H. Cooled-water pump.
I. Cold-brine pump.
J. Air-cooler.
K. Fan.
L. Fan-Motor.
M. Brine-evaporator.
N. Exchanger.
O. Crane.

Fig. 8.


Degrees For Grains per Cubic Foot
MOISTURE CONTENT OF AIR LEAVING COOLER
TEMPERATURE OF AIR ENTERING COOLER
MOISTURE CONTENT OF AIR ENTERING COOLER
Grains of Moisture Per Cubic Foot
Time of Readings

to 5 per cent., it has been reduced, owing to the regularity in working of the furnace, to 1 per cent. The increased temperature of the blast is due to the smaller quantity of air which the stoves have to deal with, and its dryness.

Several theories have been put forward to account for these economies, but it seems fairly probable that the root of the whole matter is the regularity in working of the furnace, due to the uniformity of the blast. With a varying blast, the burden should, strictly speaking, be changed to suit the different conditions, but that is impossible, since the charge is fed in at the top of the furnace, and by the time it reaches the lower zones the conditions will have changed afresh. With regular conditions, on the other hand, there is no need to carry a reserve of heat to prevent the furnace "running cold."

In regular working also the zones, wherein the different reactions take place, are not subject to displacement, and the region in which cementation of the ore by carbon monoxide takes place is greatly extended. Cementation, it is known, begins below 200 deg. Cent., is at its maximum at 450 deg. Cent., but ceases at temperatures above 800 deg. Cent. Hence a reduction of temperature in the upper zones, such as occurs with the dry blast, increases the area in which it can take place. This reduction in the case of the dry blast occurs by reason of the smaller volume of air passing into the furnace, and also because of the effect that regular working has in preventing the formation of channels or gutters in the charge, which form easy and quick by-passes for the gases. At the same time the temperature in the zone of fusion is increased, by the setting free of the heat which would otherwise have been required for the dissociation of the steam at the tuyeres, and this increase of temperature takes place exactly at the point where it is most needed, for the reduction of silicon, manganese, &c., and the melting of the iron and slag. Finally, where the conditions of working are regular, the silicon and sulphur control is an affair of very much greater exactitude, and the proportion of "off" iron is reduced.

Some critics of the dry-blast system have held that it was the incidental increase in the temperature of the blast from 720 deg. to 870 deg. Fahr. which accounted for the economies, and that the same object could have been achieved at less expense by adding to the Cowper stoves. But undried blast, heated by the same comparatively small amount, shows very little benefit; and besides the fact that heating the blast does not lessen the variation in humidity, it makes practically no reduction in the weight of the escaping gases. At the same time it is not disputed that a considerably hotter blast would not yield such a high percentage of economy when dried.

Whether these claims, which have been put forward for the dry blast, can be substantiated in all cases—and not only in those which are most favourable—by profitable returns on actual installations depends, as already explained, on the cost of plant and running charges being reduced to a minimum. At first the type of plant used did not lend itself to the achievement of this object. Refrigeration was effected in one stage only, and the actual cooling of the air was accomplished by large batteries of pipes, either direct expansion or brine circulation. These pipes had to be periodically thawed out, one section at a time, to get rid of the frost formed by the condensed moisture. It followed that the

cooling surface to be provided was enormous, particularly as the transmission of heat from more or less dry air to metal surfaces is known to be difficult. To cool 40,000 cub. ft. of air per minute, for example, the refrigerating coils had to contain 90,000 lineal ft. of 2-in. pipe. The result was that the cost of the plant, and the buildings to house it, was very high.

The first step in the way of an improvement was the application of two-stage refrigeration. Since the air has to be cooled from, perhaps, 80 deg. Fahr. down to about 16 deg. Fahr., it is clear that, if the whole of the cooling be carried out at one constant back pressure on the refrigerating plant, there will be a great waste both of refrigerating capacity and power. For that back pressure would have to be such as to produce an evaporating temperature for the ammonia within the refrigerating system, low enough to cool the air to its lowest limit, 16 deg. Fahr. On the other hand, a much higher back pressure would be quite sufficient to cool the air down to, say, 40 deg. Fahr. When the two stages of the cooling are kept separate, a different back pressure can be used for each, and this means a considerable economy, since at higher back pressures both the density and the latent heat of ammonia are increased; that is to say, the useful refrigerating effect per stroke of the compressor piston is greater. The effect is also produced with less expenditure of power per ton of refrigeration, so that the net result is a smaller plant for the same duty, operating at less expense.

Typical brine temperatures and ammonia back pressures on the two-stage system are given in the table printed below, which shows, in addition, the temperature and humidity of the air at the inlet and outlet of the cooler respectively. The brine temperatures are taken at the inlets and outlets of the different sections of the cooler, and in the first stage it will be noticed that the temperature is so high as to preclude the formation of frost. As a result, only the second-stage cooling-pipes require thawing off, and part of the duplication necessary for this purpose is saved. Most of the moisture, in fact, is condensed in the first stage, and does not have to be converted into frost at all. The figures were taken from a plant erected by Messrs. Frank C. Roberts and Co., of Philadelphia, U.S.A., in conjunction with Mr. Gayley, for the Steel Company of Canada, Hamilton, Ontario, to deal with 60,000 cub. ft. of air per minute. The cost of working on this system, when using steam as motive power, is given at 5 cents per ton of iron produced.

Table showing Results of Two-Stage Air-Cooling.

—	Air Temperature. Deg. F.		Moisture. Grains per Cub. Ft.		First-Stage Brine. Deg. F.		Second-Stage Brine. Deg. F.		Back-Pressure Ammonia. Lb. per Sq In.	
	In	Out	In	Out	In	Out	In	Out	1st Stage	2nd Stage
6 a.m.	77.7	17.0	8.50	0.77	31.5	39.0	4.0	11.5	42	14
12 m.	97.0	15.0	9.06	0.66	29.7	36.5	−0.25	7.0	39	12
6 p.m.	74.2	15.0	6.61	0.74	31.0	38.2	1.0	7.7	43	13
12 p.m.	73.0	16.5	7.72	0.73	30.5	38.0	1.25	8.7	42	15
5 a.m.	73.5	16.7	8.37	0.77	31.7	39.5	0.25	7.75	43	13

The cooling, in the Roberts two-stage plant, is on the old system of brine coils, and, while the pipe surface is more efficient, owing to part of it being not subject to frosting, it is still very bulky. The pipes are arranged in nine compartments, four for first-stage brine, four for second-stage brine, and one as a spare to enable each second-stage compartment to be defrosted in its turn. The first-stage compartments are arranged two at each end of the series, and the air passes from the two ends inwards to the centre. Shell-brine coolers and double-pipe ammonia condensers are employed, and different compressors are used for the different back pressures. The general arrangement is as shown in Figs. 1 to 4, page 126.

The two-stage system has also been adopted by Messrs. Haslam, of Derby; but in their case water instead of brine is used for the first-stage cooling. Air entering the cooler at 90 deg. Fahr. would be cooled to 36 deg. or 38 deg. Fahr. in the first stage by water, and to 20 deg. Fahr., or below, in the second stage by brine. A distinctive feature of their plant is the cooler, which marks a considerable advance on the ordinary coil system. It consists of a series of direct-expansion cooling-pipes, in conjunction with batteries of galvanised corrugated steel plates, over which the water or brine trickles. By this means the cooling surface is considerably augmented at small expense and without occupying an undue amount of space. All the frost which would otherwise be formed in the second stage is carried away in the brine, and the latter can be brought up to strength as required by evaporation, or the addition of fresh calcium chloride. There is no doubt that the pipe cooler, although it may be sufficient for American needs, where the conditions are very favourable to dry blast, is considerably more expensive and less efficient than a cooler of this type.

A later design still, and one which combines compactness with high efficiency, is the dry-blast plant of Messrs. L. Sterne and Co., Limited. After experiment a two-stage compression system was worked out and adopted, with different compressors for creating the back pressures for each stage. In this the plant is similar to others; but in the cooling arrangements a different scheme has been introduced which should give excellent results. The novel feature which distinguishes it is the use of the Heenan cooler. This cooler, which has already been described in ENGINEERING,* has been largely employed for re-cooling circulating water, oil for tempering purposes, air for chocolate and tobacco factories, &c. The appearance of the apparatus as arranged for dry-blast work is illustrated in Figs. 5, 6, and 7, on page 127, which show a cooler with a capacity of 40,000 cub. ft. of air per minute.

As will be seen, the principal parts of the Heenan cooler are a casing, a drum which revolves slowly within the casing, and a fan. The lower part of the casing is formed into a trough, which is filled at one end with water and at the other with brine, both cooled by the refrigerating plant. In the illustrations the inlet and outlet-pipes for the two liquids can be seen in front of the casing. The drum is composed of a number of cylinders placed end to end, all of which are built up, as will be seen from Fig. 5, of galvanised steel-sheeting wound in the form of a spiral on to cast-iron centres. The sheeting is wound on in such a way as to leave a small space between each two adjacent layers. At the air-inlet end of the apparatus the fan is fitted (assisted by a small suction fan at the outlet) and is arranged to circulate the air to be cooled over the upper part of the drum. The lower half, which dips into the trough, picks up thin films of cooling liquid, and, as it rotates, brings these into contact with the air, which is rapidly cooled by the enormous surface thus presented to it.

The air in its course through the cooler meets the water first, and after that the brine, and is progressively cooled by these two agents to its final temperature of 25 deg. Fahr. or below. Shell coolers are used for refrigerating the water and the brine, and the ammonia suctions from the two coolers are taken to different compressors at different pressures, so realising the benefits of two-stage compression, which have already been pointed out. An important feature in the action of the cooler is that the cooling liquids are picked up in thin films and not broken up into drops or globules, as in the cases where the liquids trickle downwards over the cooling surfaces. It follows that there is no danger of moisture being entrained by the air and carried onwards to the tuyeres.

The advantages of a plant of this description are obvious. Two-stage refrigeration reduces the size of the refrigerating plant itself, and the cooler takes up only a portion of the space occupied by the old pipe system. An inexpensive iron shed for protection from the weather is sufficient cover for the cooler, and the smaller building required for the refrigerating plant brings down the first cost still further. At the same time the cost of operation is maintained at a very low level on account of the two-stage refrigeration, and the lack of necessity for periodically thawing off.

The chart reproduced in Fig. 8, page 127, shows the constancy of the humidity with which the air leaves the cooler and the extent to which it is reduced. It will be noticed that while the air before cooling has a humidity varying from 3.5 to 11.6 grains per cubic foot, it leaves the apparatus with a fairly constant humidity, averaging about 0.75 grain. Figs. 6 and 7 illustrate the general arrangement of the complete plant, dealing, as we have stated, with 40,000 cub. ft. of air per minute. Electrically driven compressors are shown; but it would, of course, be preferable, for maximum economy, to use blast-furnace gas-engines or steam plant if sufficient waste gases are not available.

The only other type of plant which has been used is the ammonia absorption machine. One plant of this kind has been put down in this country, and several more, it is believed, are shortly to be erected abroad. In this case it is necessary to have exhaust steam at command for heating the generator, as, if steam has to be specially generated, the cost of operation becomes too high. The plant referred to was worked by exhaust steam from the blowing-engines, for which it happened that there was no other use.

(To be continued.)

* See ENGINEERING, September 4, 1914, page 313.

SHELLS; MORE SHELLS.

TO THE EDITOR OF ENGINEERING.

SIR,—So far as I am referred to in Mr. Keith's letter of the 23rd ult., I do not gather from the said letter anything which modifies the views I originally expressed, the soundness of which can hardly be in question, as they are based on well-known and fundamental facts. My attention is directed to an extract from an address given before the Cleveland Institute of Engineers on the 16th ult. May I point out that this extract contains two very big "ifs," and, consequently, cannot be conclusive.

It is reasonable to suppose that our Government have made and are constantly making tests in the direction indicated, and apparently, from Mr. Keith's letter, they are now about to try the special material he recommends. Even if the results of the tests are satisfactory, there *may* be unexpected difficulties and expenses in production or a large number of rejects. If the results are not satisfactory, the material cannot be used for the suggested purpose. Why not, then, await the full report before expressing such decided opinions on the matter? Even if successful, it is certain that the material is not one which our "general" and "ordinary" founders could handle easily, because these firms do not usually touch cast iron of the malleable variety; such material is in the hands of a comparatively few founders, and is certainly not always of uniform quality, or above criticism. Its production requires special care, and the industry may be termed a highly "specialised" one. I still think that, given a sufficient supply of steel, there is no advantage in changing.

Yours truly,
E. WHEELER.

Openshaw, Manchester, February 7, 1916.

ELECTRICAL POWER PLANTS IN THE THAMES.

TO THE EDITOR OF ENGINEERING.

SIR,—There are one or two suggestions in your correspondent's letter on the above subject, published in your issue of the 21st ult., that require a considerable amount of thought before it would be possible to put such a scheme—as a new project—before the authorities.

Mr. Dean suggests remedying our present out-of-date system by scrapping our electric supply plants and building *several* new ones in the middle of our most valuable river. What for? Simply to get the benefit of the copious supply of cooling water for condensing purposes.

Does Mr. Dean know our river, or has he had the pleasure of a trip, say, on a tug towing half a dozen barges? If he has, he will then know that the Thames is not so wide as one would like it to be at times. But apart from the question of placing obstacles in the river every here and there, creating eddy currents, interfering with the traffic, &c., he is going to put the cables and fresh-water pipes, &c., from these island stations to the shore, I presume on the bed of the river. Well, every barge, tug, and steamer has anchors, which are very often used in the river, particularly during hazy weather, and these anchors possess a peculiarity for fishing up things one does not wish for.

But apart from these apparently trifling things, and treating the matter from an economical point, why have so many generating stations on the Thames when we know from experience the advantage of a central system. He says, "the question of coal supply naturally comes up," but to remedy this, he advocates an unnecessary handling of this material. This transhipment of coal from wagons into barges is not done for nothing. Then again these barges will have to be distributed, and the coal again elevated from them to the power-house.

I suppose we can agree that the coal is the chief cost for the production of electricity in London; if so, then this is the point from which we should start. The cost of coal in London depends principally on how many times it is handled, and the distance from the colliery. The latter we cannot alter, therefore we must do our best to reduce the amount of handling.

Coal should be supplied into the place where it is consumed straight from the receptacle in which it is brought from the colliery district—either steamer or wagon; therefore we must secure a site alongside the river where we can build a wharf suitable for the discharge of modern coal vessels. At the same time it must be near some existing railway, so that in case of coal coming by trucks from the colliery, it can be emptied direct into the boiler-house. The cost of the coal of the class generally used is cheaper if brought by steamers; therefore we ought to give this the preference in the design of the plant.

We now secure the necessary land for the plant, suffi-

ciently large for future extensions. This land should be in a position alongside the wharf, so that the coal-discharging machinery can deliver the coal into the bunkers. I further suggest it ought to be on the north side of the river, so that in case of failure in the supply of coal by steamers the coal can be brought by rail without crossing London.

There could be no comparison in regard to costs between this plan and Mr. Dean's proposal, particularly in relation to foundations. I am positive of an immense saving being effected with my suggestion so far as coal is concerned, but there is also the advantage of the whole plant being centralised. I do not suggest any particular boilers, but the plant ought to be selected principally with a view of obtaining the most that is possible from the coal; probably by-products could be considered. Being at the river edge, there would still be the same copious supply of cooling water for condensing purposes. The only detriment to this idea that I know of would be the cost of transmitting the power to London and the distribution centres. Of course we should need to generate at high tension, and to transform at various distributing centres in the various districts.

I hardly anticipate any difficulty would be put forward by the Port of London Authority.

I am, Sir, yours truly,
JOHN H. ANDERSON, A.M. I. Mech. E.

Purfleet, Essex, January 22, 1916.

TECHNICAL PATENTS.

TO THE EDITOR OF ENGINEERING.

SIR,—To encourage scientific research and invention, an addition to the Patent Laws somewhat on the following lines appears desirable:—

Any novel device which embodies a discovery or the result of special knowledge or investigation, whether useful or not, or at the time of grant inapplicable to any art or trade, should be patentable. Such patent, however, should not hinder subsequent patentees from utilising it in their inventions on payment of royalty to the owner of the parent patent. For further elucidation, let it be assumed the electro-magnet is still unknown. A patent would be granted to its first maker, although it had no apparent uses above the old loadstone. Assuming dynamos to be invented during the life of the electro-magnet patent, each patentee of a dynamo would pay a small royalty and require a licence for the use of electro-magnets provided they were of the same materials and general construction as those described in the first specification. If the electro-magnet patent described the use of steel and silver wire, the use of iron and copper wire would not be considered an infringement, being a newer discovery.

Yours faithfully,
Derby. E. D. HEARN.

BRITISH PATENT LAWS AND FUTURE GERMAN TRADE.

TO THE EDITOR OF ENGINEERING.

SIR,—Your correspondent Mr. James Keith's letter in your issue for February 4, 1916, should certainly awaken inventors and manufacturers to the unsatisfactory state of our legislation in the matter of patents.

I fully agree with Mr. Keith as regards points 1, 2, 4 and 6, and the concluding paragraphs of his letter.

As long as we have lawyers in Parliament we shall not get a proper Patent Act, not one even as good as the German Patent Laws, which should be the basis of a new British Patent Law.

But I think the most absurd part of our Patent Laws is the Patent Rules. On considering the vexatious regulations of our Patent Office, I wonder how it is that the British public will put up with its penalising stipulations.

For instance, why should an application for a patent have to be accepted within fifteen months. If the real search mentioned by Mr. James Keith is to be adopted, it will not, in many cases, be possible to make a thorough search within fifteen months, especially when one remembers that it takes sometimes *seventeen years* to get an application through in the United States.

This Department of the State—the Patent Office—seems always to be *on the make*, as for every little infraction of the rules you are penalised. Take, for example, the International Convention case. Why should a foreign applicant be compelled to file the certified copy at the same time as the application for the British patent, or else to have to pay a fine? There is not a single Patent Rule which is not vexatory; it is always pay and pay.

The duration of a patent should be *twenty-one years, and start from the date of grant*, as in the United States and Austria. The renewal fees should be moderate—not exorbitant, as they are now. I am not in favour of the abolition of renewal fees, nor do I think that any Government could honestly give a guarantee to any inventor.

We are talking a good deal about capturing the enemy's trade, but in the meantime the Government seems to do as little as they can to promote this end, especially as regards private searches on novelty. It has been a wonder to me why the Patent Office Library should close at 5 p.m., so that it is impossible for any person interested in any trade or manufacture to consult the records of patents and technical literature. That the former closing hour was unduly late is admitted, but why should the Patent Office Library now close at 5 p.m. every day except Saturday, when it closes at 1 p.m.? Do we mean business, or do we mean to let the Germans have all their own again after the war?

If the Patent Laws are to be overhauled, the Rules of Practice must be amended accordingly, for as they stand they are most illiberal. Because this war is a pretext to humbug people in many walks of life, why should inventors, manufacturers, engineers be hindered by such idiotic rules in the furtherance of British trade and industries as those which still obtain in the matter of industrial legislation?

One of the most unjust things exacted by this Government is that there is no *moratorium* about renewal fees, or even application fees. Although there is a terrible war going on, the British Government exacts renewal fee on patents. No wonder the French Government now insists on the payment of application fees and renewal fees on French patents applied for by, or granted to subjects of, foreign States who have not granted a moratorium to other countries.

The British Patent Laws, like a good many laws, are a downright disgrace to this country, and it is high time that a more liberal and rational legislation should replace the 1907 Patent Act; but have we got a Government capable of carrying this out?

Yours truly,
London, February 7, 1916. MERNOK.

TO THE EDITOR OF ENGINEERING.

SIR,—The letter of Mr. James Keith in your issue of February 4 calls attention to a matter of interest and importance at the present time. May I be permitted, however, to call attention to one or two points raised by that letter, as possibly my view, necessarily taken from a different aspect, will prove of interest?

Mr. Keith points to several grievances due, he states, to the Patents Act of 1907 and 1914. As regards his grievance No. 1, I would beg to point out that no person can directly apply to revoke a British patent on the ground that a foreign patent for a similar invention has been granted or published years previously. This argument is only possible as an answer to an infringement suit. This undoubtedly is a defect in the present law.

As to the last part of his grievance No. 1, with regard to the International Convention; frankly, I do not follow the same. The International Convention rules no harder against Great Britain than against other countries. Certain countries, indeed, have their own Conventions, such as that, for instance, existing for working conditions between Switzerland and Germany and the United States; but in other respects the British inventor is decidedly in a better position than the citizen of any other State, and he has in addition peculiar rights in regard to certain British colonies.

As regards his grievance No. 2, by which he states that any German may appropriate a British invention after a British patent has been granted to a British inventor, presumably in Germany, I would state that this at present is not possible, because the German Patent Office have decided not to grant patents to any subjects of the allied nations until the war is over. Mr. Keith is, however, probably right as regards certain opposition proceedings conducted before the war. I have had experience of cases—I believe they are, however, rare—where the British inventor had not the same advantages in the German Court as the German opponent. This was due, in the cases which I have in mind, to the fact that the German person had already been manufacturing, or could prove a *bona fide* intention to manufacture, in the interim immediately before the British subject applied for a patent, whilst the British person was not manufacturing, and consequently the German Patent Court adopted the "easiest way," which was to grant the patent rights to the person on the spot who had the industry established.

Grievance No. 3 states that a patent can be obtained in this country for an impracticable invention and one which is novel only in so far as the British patent search goes. The search is, as he says, limited to specifications filed in Great Britain within the last fifty years. I have heard it expressed, however, by Patent Office officials that their search is well done in a small field, in contradistinction to the searches in the United States and Germany, being only cursorily done in a very large field. Undoubtedly, however, the actual result is that an application in the United States gets a better testing than one in England in the general run. I would point out, however, that in no case can a search ever be final. Neither the United States nor German search is infallible, and there is no more guarantee that a patent is valid when granted in the United States than there is on an application granted in England. Only by the ideal, unfortunately unattainable, of the whole literature of the world accurately classified, and a search made throughout this, would it be quite possible to guarantee the validity of a patent. A *real* search therefore is impossible in practice, as also is point 2, that no patent should be granted unless practicable. The Patent Office cannot determine if an invention is practicable or not. Often the "pinch of salt" difference between what is already known and a new patent application has meant an enormous advance in industry due to that patent. I could cite many cases where a small difference negligible to the layman has in practice resulted in extraordinary progress, and, consequently, one should avoid the rejection of patents on the mere off-hand opinion of a Patent Office official, who, however conscientious, would rather be on the safe side and reject the patent than pass it. Most famous inventions are famous only because they happen to have been presented to the world at a favourable moment. There are few the novelty of which surpassed what I have termed "the pinch of salt," *e.g.* the automatic loom, the sewing-machine, the aeroplane.

As a third suggestion, he makes the entire abolition of all renewal fees, as in the United States. This sounds to be very desirable, but I would point out that it is by no means as desirable a condition as at first it would appear, because the industry in general would be hung up by patents of which the owners had died or had lost all interest in their applications; and, further, persons would take out patents to merely block others, and yet not utilise them themselves, and seventeen years is a long time for the public to wait for freedom and to obtain their share of the bargain; for, after all, a patent is but a contract or bargain between the State or public and the individual inventor. I would suggest that the ideal system in regard to this is that obtainable in Canada, wherein renewal fees are payable at the sixth and twelfth year. Consequently, if the inventor has no more interest in the matter after the sixth year, then it becomes public property; but he can extend it for six-year periods on the payment of renewal fees. By adopting such a term, one gets patents lasting six, twelve, or eighteen years.

As regards the sixth suggestion of Mr. Keith, I completely agree with him. Litigation upon a patent at the present moment is an enormously expensive matter, and very complicated. As an improved method, I would suggest that all matters be dealt with in the Comptroller's Court, similar to oppositions at the present moment. Where appeal is necessary, this should be made to the Law Officer, or such single individual person, and if necessary further appeal to a tribunal such as the House of Lords; but this latter step should be made a very difficult and comparatively rare one. The cost then of defending one's patent, or attacking an infringer, would be very small, almost nominal, compared to the cost now of going to the High Court.

He states that patent counsel, lawyers, and patent agents should no longer have the drafting of Patent Acts. I have not been aware that so far they have had much of a say in the draftings of Patent Acts. They have expressed, indeed, certain opinions; but, I believe, Chambers of Commerce in such places as Manchester have given suggestions and the Board of Trade have drafted the Act; but in this point I may be wrong.

I would point out that logically the interpretation of the Patents Act, being a legal document, must necessarily be left to lawyers, using the term in the broadest sense. Consequently, it follows that the Act should be drafted by lawyers, again in the broadest sense. Where the system has previously suffered has been that the "lawyers" chosen have not been of the correct sort. Solicitors, barristers, and judges taken generally are too legal and too little scientific; there are, of course, some notable exceptions. I beg to submit, with deference, that patent barristers and patent agents are best able to appreciate the practical defects in the Patent Laws and their practical remedies. They not only come into direct contact with the inventor, but also they are experienced in the working and interpretation of the law. Engineering societies and organisations might well have a say in the drafting of amendments to any Patent Act, because these societies cover by their membership almost the whole field. They represent inventors, they represent the manufacturing industry, and just that amount of expert knowledge and law that is necessary.

I have known cases where inventors, expert engineers, and university professors have themselves not appreciated what exactly they have themselves invented. For proof of this one has only to examine patents at random, where the man has been his own patent agent; the claims are usually narrow or, broadly, obscure. He has neither the legal mind nor the experienced technical appreciation necessary to draft the techno-legal document. After arduous experiment an inventor happens upon a successful issue, and one might state that he rushes into print on that successful issue, totally overlooking the secret of that issue—the principle which he has discovered. It is nonsense to say that a patent cannot be granted for a principle. Every good patent stands on a novel principle; but how few inventors realise the new principle which they have discovered. Many, impressed by their success and the labour it has entailed, think that as they have obtained one satisfactory solution of a problem, that therefore they were entitled to protection for the desiderata. That is to say, an inventor, obtaining a means of reducing the sparking of commutators, immediately wants to claim as his own particular property every sparkless commutator. The Patent Office soon disillusions him, and probably he gets a narrow patent for the particular arrangement he has devised. If he goes, however, to a capable patent agent, that adviser should draft and obtain for him claims which cover the essence or principle of the invention, and procure him thereby a field of monopoly actual and substantial.

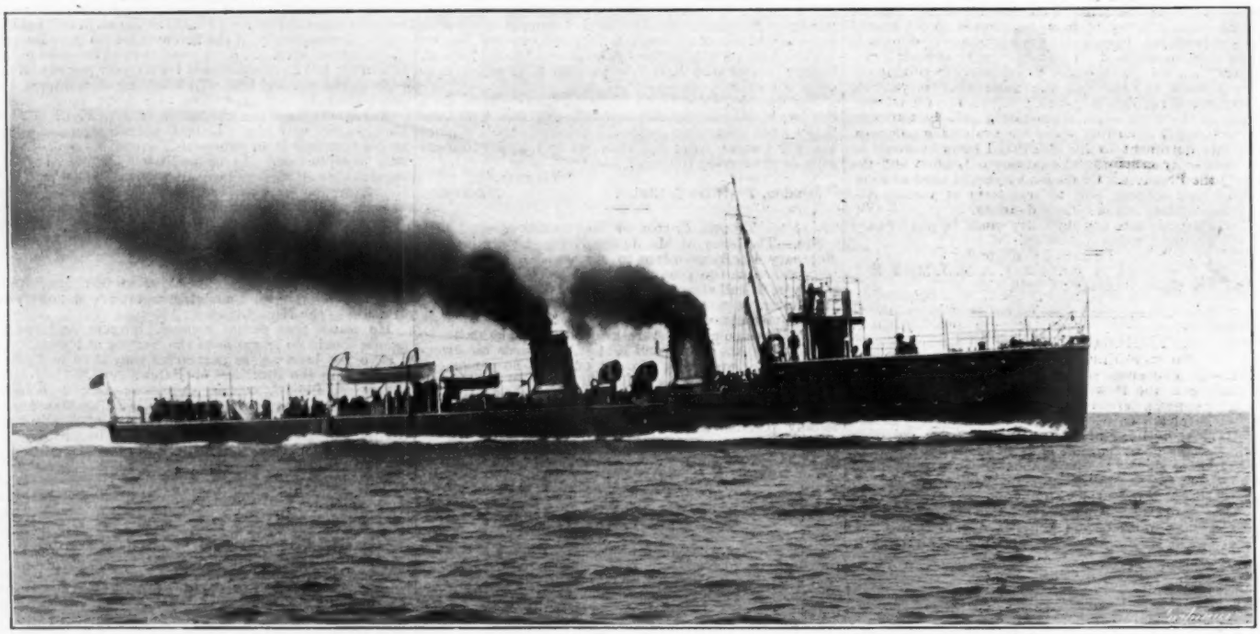
Yours truly,
J. VICTOR ARMSTRONG,
Fellow Inst. Ch. Patent Agents, Mem. Textile Inst.
6, Lord-street, Liverpool, February 9, 1916.

THE PANAMA CANAL.—To the close of June, 1914, the total receipts of the United States Government for the purpose of the Panama Canal amounted to 360,920,975 dols., including Congressional appropriations, of 352,205,669 dols., and miscellaneous receipts from water rentals, sale of Government property, &c. The total expenditure upon the canal to the close of June, 1914, was 349,555,834 dols., leaving an available balance of 11,365,141 dols. Nearly two-thirds of the canal expenditure was paid from current revenues, bonds only having been issued to the amount of 135,000,000 dols. At the close of the American fiscal year, 1914-15, comprising a period of 10½ months, from August 14, 1914, the traffic which passed through the canal was 1088 vessels, carrying cargoes representing a total of 4,969,792 tons. In these totals, 530 vessels, and 2,125,735 tons, were eastbound, and 558 vessels, and 2,844,057 tons, westbound. The tolls collected from the canal in 1914-15 amounted to 4,424,256 dols.

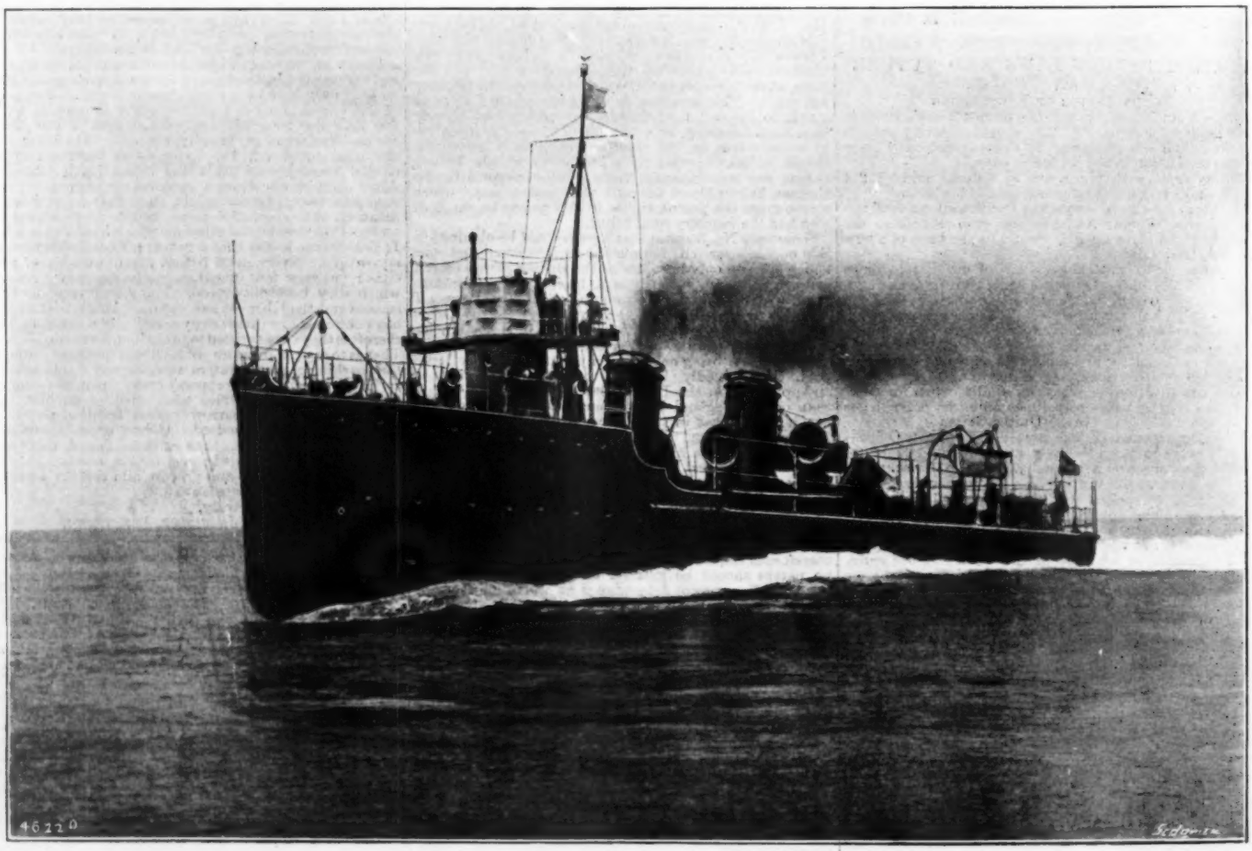
SPANISH TORPEDO-BOAT DESTROYERS OF THE "BUSTAMANTE" CLASS.

CONSTRUCTED BY THE SOCIEDAD ESPAÑOLA DE CONSTRUCCIÓN NAVAL, CARTAGENA, SPAIN.

(For Description, see opposite Page.)



The "Bustamante" on Trial.



Steaming 29 Knots.

SPANISH TORPEDO-BOAT DESTROYERS OF THE "BUSTAMANTE" CLASS.

CONSTRUCTED BY THE SOCIEDAD ESPAÑOLA DE CONSTRUCCIÓN NAVAL, CARTAGENA, SPAIN.

Length	*... 220 ft. (67.05 m.)*
Breadth	*...22 ft. 2 in. (6.75 m.)*
Depth	*... 13 ft. (3.96 m.)*
Draught	*...5 ft. 6 in. (1.676 m.)*
Displacement	*370 tons*
S.H.P. on four hours' trial	*9020*
Speed on four hours' trial	*29.15 knots*

Fig. 5. FORECASTLE

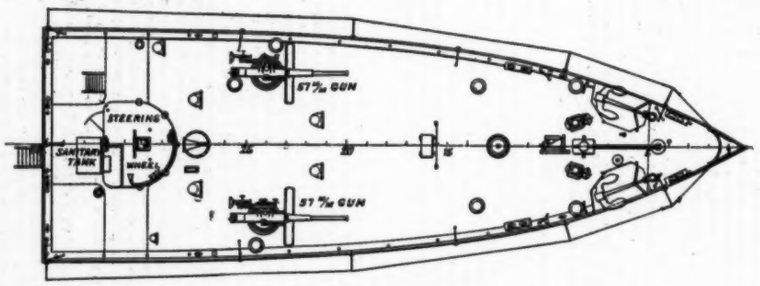


Fig. 6. BRIDGE.

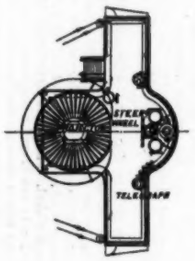


Fig. 7. FRAME 13.

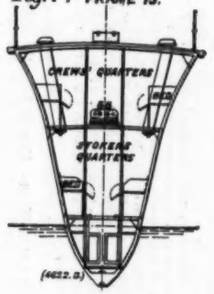


Fig. 8. FRAME 32.

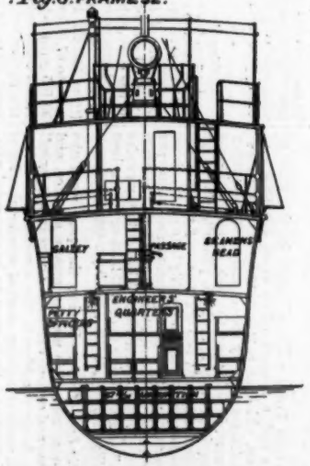


Fig. 9. FRAME 59.

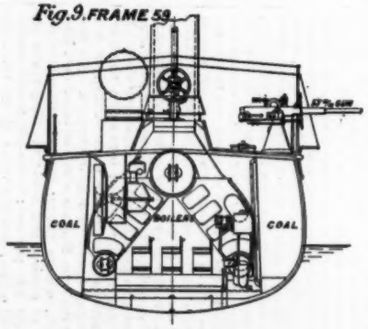


Fig. 10. FRAME 86.

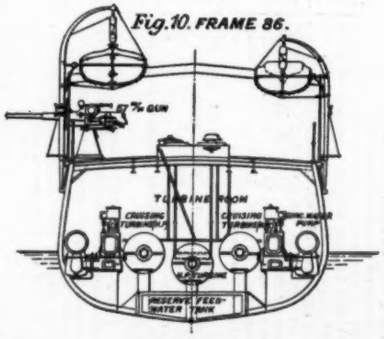


Fig. 11. FRAME 106.

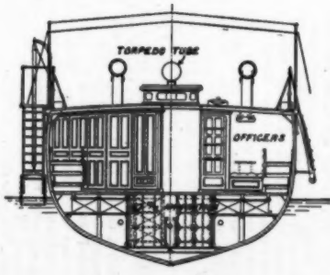
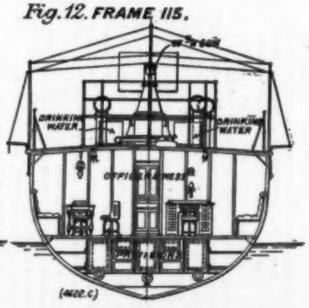


Fig. 12. FRAME 115.



AMONGST the ships whose construction was entrusted to the Sociedad Española de Construcción Naval by the Spanish Government, under the law of January 7, 1908, were included the torpedo-boat destroyers Bustamante, Villamil, and Cadarso, named after naval officers of the Spanish Royal Navy who died gloriously for their country in Cuba and the Philippines during the Spanish-American War of 1898. The first of these brave officers, Don Joaquin Bustamante, was Chief of the General Staff of the Fleet under Admiral Cervera, and was killed whilst leading the Marines to the assistance of the land forces, who were endeavouring to prevent the entry of the American troops into Santiago (Cuba). The second, Don Fernando Villamil, who was in charge of the destroyer flotilla in the engagement which took place in the vicinity of the aforementioned harbour on July 8, was killed aboard the Furror. The third, Don Luis Cadarso, succumbed at Cavite (Philippines), whilst in charge of the cruiser Reina Christina, which was totally destroyed by the enemy's ships.

The three vessels which bear these distinguished officers' names represent the latest practice in the design of vessel which has been very prominent during recent naval engagements, and we give longitudinal section and deck plans on Plate XIII.; the plan of the forecastle and bridge and cross-sections are given on this page, and two perspective views of the first of the class on trial are reproduced on page 130.

All three vessels are being built at the Cartagena Arsenal. The principal dimensions are :—

Length	...	...	...	220 ft. (67.05 m.)
Breadth	...	...	...	22 ft. 2 in. (6.75 m.)
Depth ...	...	...	...	13 ft. (3.96 m.)

On a draught of 5 ft. 6 in. the displacement is 370 tons, and the turbine machinery was designed to give a speed of 28 knots, but on the four hours' trial 29.15 knots was realised.

The drawings reproduced are so detailed that little description is necessary. Fig. 1 is a longitudinal section, and shows not only the subdivision, but the arrangement of the various compartments. Fig. 2 is the upper-deck plan, and from this it will be seen that the vessel on this level mounts three guns of 57 mm., in addition to two on the forecastle head, one on each beam, as shown in Fig. 5, but with a very wide arc of training. The after gun is mounted on a high platform, as shown in Figs. 1 and 2, with a practically all-round fire. In addition, the ship carries two 457-mm. torpedo-tubes, mounted on the engine and boiler casings respectively, as shown in Figs. 1 and 2. It will be seen, further, from Fig. 2, that the vessel carries on davits a whaler and one dinghy, while two Berthon boats are placed on chocks, on each side near the mast, the derrick on which is utilised for handling them. The deck machinery is also shown in Fig. 2, and the plan of the forecastle in Fig. 5. There is a steam capstan and cable-stopper. The steering-gear is in the engine-room, and the rudder, as shown in Fig. 1, is of the balanced type.

The lower-deck plan, Fig. 3, shows the accommodation for the officers and crew. The state-rooms of the commander and four officers are aft, with the ward-room adjacent, and further details of these are shown in the cross-sections, Figs. 11 and 12, while the engineers and petty officers are berthed in two rooms immediately forward of the boiler-room bulkhead, as further shown in the cross-section (Fig. 8), while in a separate compartment, further forward, is the accommodation for the firemen. The crew are berthed on the upper deck under the forecastle head, as shown in Fig. 2. Here also the galleys and crew's lavatories are located. Fig. 4 is a hold plan, and shows the machinery of the ship and pumping arrangements, as well as stores. The pumping and draining arrangements include a suction main, with branches under all the main compartments and connection to the steam bilge-pumps in the engine-room, and to a pump placed on the boiler-casing. Steam-ejectors, having a capacity of 40 tons per hour, are also fitted in all the main compartments.

The navigating-bridge is shown in Fig. 6, and it will be seen that there are all the usual telegraphs and a powerful searchlight mounted on a circular table. The other cross-sections annexed are further illustrative of the general arrangement of the ship. Fig. 7 is a section at the forecastle, showing the crew's and stokers' quarters. Fig. 8 is a section at the bridge, and shows the accommodation provided for the engineer officers, with the magazine for the 57-mm. guns below. Fig. 9 is a section through the boiler-room, and Fig. 10 through the engine-room; but as we intend, in a succeeding article, to give further drawings of the machinery, with description, no further reference need now be made to this section. Fig. 11 is a section showing the accommodation for the officers, with the magazines for the 57-mm. guns below; while Fig. 12 shows the ward-room, with the store below, and on the deck above the central platform for the stern 57-mm. gun.

(To be continued.)

ELASTIC TRANSVERSE RAILWAY SLEEPERS.—The present local scarcity of wood once more draws attention to the advantages of iron over wooden sleepers, as to which there remains a good deal of diversity of opinion. A new kind of elastic hollow sleeper was suggested last October in the *Zeitschrift des Vereins Deutscher Eisenbahnverwaltungen* by Dr. Saller. The suggestion does not look very likely of being adopted; but all sorts of things are tried for special purposes now. The sleeper is to be rolled to such a shape that its cross-section forms an oval loop open below. The top is flat, and bears two lugs or ribs, against which the rails are to rest. The sides of the plate, from which the sleeper is rolled, are bent over so as nearly to touch one another below; the gap between the edges, near which the plate is left practically straight (unbent), can widen out and close with pressure and temperature changes. The plate thickness tapers down from 9 mm. between the rails to 5 mm. at the edge; the total width of the sleeper is 260 mm., the height 160 mm. The rolling of such sleepers would certainly be expensive.

SCREW-CUTTING IN ALUMINIUM.

THE cutting of perfectly clean threads in aluminium, either by machinery or by hand-power, is a problem which has tried the patience of many an engineer. In a screw-cutting or a tapping machine, the metal tears away, notwithstanding the lubricant hitherto used, and a large proportion of the threads are destroyed in the process, or are imperfect. When cutting the threads by hand-power—a kind of hard labour when the lubricant used is unsatisfactory—the same defects generally occur, or when they do not, the threads are not clean and uniform throughout, for the point at which the man stopped to give another fraction of a turn to the screw or die-stock is marked by dents and raised portions on a series of the threads and over the whole threaded depth. Such difficulties, however, generally give way in time to patient experimenting, and in this case they appear to have done so, for quite recently we had the opportunity of seeing inside taper-threads cut with cleanness and accuracy by the aid of a new lubricant. The job in hand was an order for aluminium adaptors for shells, and naturally ran into very large numbers. Under the old conditions it was slow and not satisfactory, but with the new lubricant the adaptors were turned out at the rate of sixty to seventy per hour by two boys. The lubricant also increases the life of the screw-taps, one pair we saw having cut as many as 7000 aluminium adaptors. This lubricant is also of great value for other processes in the manufacture of aluminium articles, especially turning and machining, a great increase in output being obtained. We do not know the constitution of the liquid, and even if we did it might not be desirable to publish it under existing conditions. It is the discovery of the Tolgate Engineering Company, of 9, Glengall-terrace, Old Kent-road, London, S.E.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, January 26.

IT is quite correct to say that a very large volume of business is offered, but not accepted because of the congested condition of railroad freights. The export volume is slightly increasing; every domestic interest is made, as far as possible, subservient to exportation of munitions; for awhile railroad orders were held up by high prices; as higher prices have since then predominated, railroads are coming in to cover absolutely necessary requirements; among them is a Pennsylvania railroad order for 5000 steel cars and 150 locomotives, to be built at the Altona shops; orders are pending for 10,000 cars; orders for rails this week, 50,000 tons, in the West. Export orders for rails were 60,000 tons for 1917 at 38 dols. Sea-bound delivery, 4000 tons for India and 2000 tons for Africa. Two ore-carrying boats are being built, calling for 10,000 tons of plates; also a boat for Norway; two oil-carriers are to be built on the Pacific Coast, as Atlantic yards are crowded. All iron and steel prices must advance, because wages are advancing. Pig-iron users are buying irregularly, only as they need material. Much Virginia iron, due in New England, cannot be delivered; but there are signs that the embargo will soon be lifted. Heavy orders for structural steel still flow in, though promised deliveries are disappointing.

Mills are called upon to make known as fast as they can their ability to make deliveries, and the highest on the list of standing orders are then booked. Notwithstanding much over-sold conditions, export orders are still taken; one recent order was for 30,000 tons for the second half delivery for steel bars, and France is still working at the placing of 500,000 tons of heavy steel material through 1917. Export billets are badly wanted, but are unavailable just now; of course, new capacity is being hurried along. Eastern mills are sold up tight until July; all prices are up. There is plenty of general inquiry for every mill product. Iron bars are higher, sheets, of course, are active, and tin-plates are wanted faster than mills can furnish them, even at 4 dols. per box for export, against 3.75 dols. to 3.90 dols. domestic. The railroads are facing a mighty struggle with all classes of railroad labour, and several hundred thousand miners are preparing to go on the war-path for radically new conditions; the combined condition of dissatisfied labour represents over three-quarters of a million skilled labourers, and the prospects are anything but assuring.

THE INSTITUTION OF ELECTRICAL ENGINEERS: EXPULSION OF ENEMY MEMBERS.—As soon as the approval of the Board of Trade is obtained, the Council propose to call a special general meeting of the corporate members to consider and, if approved, to adopt the following addition to the Articles of Association:—Addition to Article 41:—"(a) In the event of a state of war arising between Great Britain and any other country or State, any member of any class who at any time during such war shall be a subject of such enemy country or State shall forthwith cease to be a member of the Institution; and in the case of the European War of 1914 all such members shall cease to be members of the Institution on and after ——————." (The date to be inserted will depend on the date of confirming the resolution.) The Council have also received a petition signed by seventeen corporate members in regard to the expulsion of enemy aliens, asking that, in accordance with Article 80, the Council call a special general meeting for the purpose of dealing with the matter. It is understood that the signatories are of opinion that the alteration proposed by the Council will effect the object of the petition.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Thursday morning's market not only continued firm, but further improved upon the prices which had been such a very notable feature of the earlier part of last week, cash iron rising to 87s. 3d. per ton, and closing with sellers at 87s. 9d. On forward account up to 88s. was paid for one month's iron, sellers at the close quoting 88s. 1½d. per ton. Business amounting to 2000 tons was dealt in. One month's iron changed hands in the afternoon at 88s. 2d., and some business was also done in three months' warrants at 88s. 6d., sellers' prices at the close being 87s. 9½d. cash, 88s. 3d. one month, and 88s. 6d. three months, while the transactions amounted to 1500 tons. On Friday morning a further advance took place, and 4000 tons were dealt in at 88s. 2d. per ton cash and 89s. one month. Dealings took place at some odd dates, 88s. 6d. per ton being realised for seventeen and twenty-one days; 88s. 7½d. seven days; and 89s. twenty-one days; and at the close sellers held out for 88s. 9d. cash and 89s. 3d. one month. Business was rather quiet in the afternoon, with prices a trifle below the morning's level. One warrant was the only transaction recorded, and for this 88s. 10½d. one month was paid. Closing sellers quoted 88s. 7d. cash and 89s. 1d. one month. Over the week, pig-iron warrants advanced 6s. per ton, a very uncommon occurrence, while the advance since the beginning of January amounts to fully 10s. per ton. The current rates certainly constitute a record. Monday morning showed further progress, 2500 tons changing hands up to 89s. 3d. per ton cash, with sellers over at the close, while 89s. 2½d. was realised for seven days, and 89s. 8½d. one month, these prices being 8d. per ton over Friday's level. At the afternoon session values advanced rapidly, and 1500 tons were put through at 89s. 10½d. cash and 90s. twenty-one and twenty-four days. At the close sellers quoted 90s. 3d. cash and 90s. 9d. one month, a rise of 1s. per ton from the forenoon. This, however, was completely eclipsed yesterday (Tuesday) forenoon, when Cleveland warrants rushed up a further 3s. per ton to 93s. 3d. cash and 93s. 9d. one month, after being dealt in at 91s. 6d. cash, 93s. nine days, and 93s. 3d. one month. Business was restricted to a small turnover of 1500 tons. Although 4500 tons were dealt in at the afternoon market at 93s. 3d. cash and 94s. one month, prices fell off at the close, when sellers quoted 92s. 9d. cash and 93s. 2d. one month. For thirteen days 93s. 3d. to 93s. 2d. was quoted. A reduction as sudden as was yesterday's rise was recorded at this morning's market, and cash iron dropped to 91s. per ton and one month's to 91s. 6d., with sellers over at these figure at the close. Business was confined to a small matter of 1500 tons.

Sulphate of Ammonia.—During the past few days sulphate of ammonia has been slightly easier, due, no doubt, to the restrictions with regard to export, and prices are still on the level of 17*l.* 17s. 6d. to 18*l.* per ton or thereabouts for prompt delivery Glasgow, and 18*l.* or so for prompt delivery Leith.

Scotch Steel Trade.—No material change in industrial conditions has taken place during the past week, and the local steel-makers still report an excessive output of all classes of steel material, more particularly that required for munitions. Light plates of every description are in exceptional demand, but unless these are required for Government work, considerable delay in regard to delivery invariably takes place. Neither is it possible to procure sections for ordinary mercantile purposes, as the Munitions Department practically absorbs the entire output of all the available angle-mills. In addition to this, all specifications for steel material placed with local manufacturers must be submitted to the Ministry of Munitions, whose sanction is necessary before the order can be accepted. Much delay is frequently occasioned by this restriction, which, however, has been rendered unavoidable by the unprecedented conditions now ruling. The demand for high tensile-steel bars for shell-making continues unabated, and as soon as these are rolled they are sent off with the utmost despatch to the different munition works, where the shells are shaped, turned, and finished. A further increase in the price of raw materials is adding to the difficulties experienced by the Ministry of Munitions in fixing a maximum price for all manufactured steel. If this could be satisfactorily carried into effect, there are distinct indications that better trade conditions will rule in future than have ever done in the past. An idea is abroad that the price limitation will be based on a kind of sliding scale, always taking into consideration the current rates of pig-iron and hematite. Ship-plates are still quoted 12*l.* 10s. per ton; boiler-plates and angles, 13*l.* 10s.—all, of course, less the usual 2½ per cent. discount.

Malleable-Iron Trade.—The advance in the price of pig-iron has had a marked effect upon the values of malleable iron, which are now firming up in consequence. Business conditions are very active, and an extraordinary amount of work is being put through by malleable-iron makers. Inquiries from abroad are plentiful, and were the Government demands less heavy, a very considerable increase in the export trade could easily take place. Some talk has leaked out that arrangements are being put forward for the laying down of new plant to deal with the future supply of raw material. While ordinary grades of "Crown" bars are being quoted 13*l.* 5s. or so, the best quality readily realizes 13*l.* 10s., less 5 per cent. discount.

Scotch Pig-Iron Trade.—During the past week the Scotch pig-iron trade has made a steady advance, and both for home and export excellent business is reported. Indeed, all things considered, the amount of business being put through is nothing short of wonderful, with so many restrictions and limitations to be contended with. The fact that all pig-iron must be certified before being shipped means, in almost every case, a considerable delay, while the necessary entries are being made and the certificates filled in and granted; and with hematite things are even more involved, the special licence required proving detrimental to a speedy despatch. For local consumption there is a constant demand for hematite, it being disposed of freely to the various steel works. Foundry iron is also much stronger than it was some little time ago, and is in good demand for export. The improved conditions are traceable to a reduced production. Last week's quotations for makers' (No. 1) iron has been considerably increased, as the following table shows:—Clyde and Calder, 112s. 6d. per ton; Gartsherrie, Langloan, Summerlee, 115s. (all shipped at Glasgow); Eglinton, 107s., Glengarnock, 112s. 6d. (both at Ardrossan); Dalmellington, 107s. (at Ayr), and Shotts, 115s. (at Leith).

THE LYONS FAIR.—French journals announce that a fair is to be held in Lyons from March 1 to 15. Its object is to replace the Leipzig Fair and to establish direct communications between merchants and manufacturers, with a view to do away entirely with all articles, whatsoever they may be, which formerly proceeded from Germany and Austria-Hungary. All necessary information can be obtained from the Mayor of Lyons.

GERMAN METAL FAMINE.—Although the Germans are very proud of their success in the matter of substitutes for articles the supply of which the war has put a stop to, there are commodities for which they have not yet managed to find any *Ersatz*. This applies to copper, brass and nickel. The voluntary giving up of these goods has evidently not brought the desired result, for now the State has taken the extraordinary step of expropriating all household articles made of these metals. These things no longer belong to the former owner, but to the State. Lists are supplied, which have to be filled up, and the former owner receives in payment for his household articles their value as scrap metal. A professor at the Berlin University has publicly protested against this system of remuneration. Upon its voluntary surrender, he received 84 pfennig (9d.) for a copper can that had cost 7 marks; but this was a voluntary offering; but now he has been compelled to give up a brass kettle, which cost 17 marks 50 pfennig, for which he received 2 marks 90 pfennig, and, further, he had to buy an enamelled kettle to use in lieu of the brass one, at a cost of 8 marks. This is but one example, but it shows plainly enough the condition of affairs.

METROPOLITAN RAILWAY.—The opening of a new viaduct at Kilburn, forming the last section of the widening of this railway between Finchley-road and Wembley Park, has attracted considerable traffic to the system, as the train services have been improved by the new lines brought into operation. Under the terms of the working arrangement with the Government, no benefit accrues at present to the Metropolitan Company, however, from the earnings of new lines and works brought into use since 1913, although the company has to pay interest on the capital raised. Representations have been made to the Government upon the subject, and it is expected that the equity of the company's claim will be recognised. The expenditure made in 1915 for widening and improving previously existing lines was 84,413*l.* An outlay of 31,070*l.* was also made for additional rolling-stock. Altogether, the additional capital expended last year was 125,582*l.*, carrying the total outlay upon capital account to 18,101,063*l.* It is estimated also that further capital will have to be paid out in 1916 to the extent of 107,800*l.* The company's passenger rolling-stock is classified under two heads: viz., electric locomotives and carriages, and steam locomotives and coaching vehicles other than electric. The number of electric locomotives owned at the close of last year was 21. There were, also, 8 motor-coaches and 153 motor-cars upon the system. The company's metropolitan lines, properly so-called, are worked almost wholly by electric locomotives and motors, while steam locomotives supply power upon the country lines.

ROUMANIAN PETROLEUM EXPORTS.—Some statistics are now available, bearing both upon the exports of Roumanian petroleum for the first ten months of 1915 and giving detailed information as to the movement of the trade in 1914, as regards the different countries. For last year there is a very material falling off, the aggregate for the first ten months of the year being 349,400 tons, against 586,973 tons for the corresponding period of 1914—a decline of 237,573 tons, or 40 per cent. It must, however, be remembered that of the ten months of 1914 seven were peace months and only three war, and yet the year 1914 compares very unfavourably with the preceding year, as will appear from the appended table:—

	1913. tons	1914. tons
Lighting oil	418,622	297,800
Benzine, raw and refined	237,168	164,143
Aggregate export of petroleum products for the two years	1,036,446	654,024

On account of the war only the above 654,024 tons were exported out of a total production of 1,733,947 tons, or 36 per cent., whilst in 1913 56 per cent. were exported. The decrease in the exports for 1914 relates principally to England (from 232,880 tons to 77,971 tons), France (from 151,402 tons to 50,028 tons), Egypt (from 121,642 tons to 67,214 tons), and Germany (from 126,295 tons to 99,165 tons), whilst the exports to Austria increased (from 77,184 tons to 84,253 tons). It should be observed that the figures for 1914 have been withheld by the Government till quite recently.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—There is an active demand for all classes of steam coal, cobbles and small fuel, works having difficulty in securing a sufficiency of supplies to meet their steadily increasing requirements. Up to the present deliveries have been of a somewhat haphazard character, but a Committee has now been appointed to equalise the distribution among the controlled works, and an improvement is anticipated. The colder weather has caused an increasing inquiry for house coal, deliveries being as regular as railway facilities will allow. Export licences being granted less freely, shipments to other than Allied countries are very small. The market for small coal is in an unsettled condition, and supplies fall short of requirements. Little of this fuel is for sale on the open market after the Government needs have been met. A good tonnage of gas coal is going to inland works on contract account, and shipments, especially to the French ports, are on a fair scale. All qualities of slacks are in strong demand, and collieries have a large number of unfulfilled orders on their books. The market for blast-furnace coke is still active, and business this week has been good at the maximum rate of 24s. on rail at ovens. Quotations:—Best branch hand-picked, 20s. 6d. to 21s. 6d.; Barnsley best Silkstone, 17s. 6d. to 18s. 6d.; Derbyshire best brights, 17s. 6d. to 18s. 6d.; Derbyshire house, 16s. to 17s.; best large nuts, 15s. to 16s.; small nuts, 14s. 6d. to 15s. 6d.; Yorkshire hards, 16s. 6d. to 17s. 6d.; Derbyshire hards, 16s. to 17s.; best slacks, 11s. to 12s.; seconds, 9s. 6d. to 10s. 6d.; smalls, 8s. to 9s.

Iron and Steel.—Great activity prevails in the iron and steel industries of the district, and, with the installation of new plant and machinery, increased output is general. The capacity for steel-making has considerably increased during the past twelve months, and there is no indication that extensions are yet finished. A difficulty experienced by munition and other firms in securing machinery has been met by the authorities practically prohibiting the supply of new machines to any but those firms engaged on important national work, and regulating the delivery to meet necessities. The inflated price of materials is causing a good deal of heartburning to the management of the pig iron and steel concerns. Maximum prices are supposed to exist; but, if this is the case, they are being widely ignored. Hematites have again advanced. There is considerable scarcity in this class of iron, practically the whole of the output being taken up on contract for immediate consumption for ourselves and our Allies. Considerable difficulty is being experienced in obtaining any fresh supplies. The latest quotations delivered in Sheffield are:—West Coast, 150s.; East Coast, 146s.; but higher rates than these are heard of. Foundry and forge irons are in improved demand. Lincolnshire No 3 foundry, also delivered in Sheffield, is making 91s. 3d.; Lincolnshire forge, 90s. 3d.; Derbyshire No. 3 foundry, 84s. 6d.; Derbyshire forge, 82s. 6d. Advances are also noticed in steel hoops, which are now quoted at 17*l.* 2s. 6d., and sheets, which advanced 1*l.* to 18*l.* Bars are still quoted at 13*l.*, which has been the selling figure since the commencement of the year. A notable increase has taken place in the output of alloy steels, largely used in the construction of automobiles, aeroplanes, &c. New electric furnaces have been erected, and a steadily improving business is being done. Orders for cutlery, augers, electro-plate, knives, spoons, and saws figure in this week's overseas business. Steel in various forms is wanted in Canada, Australia, and South Africa, and, judging from the high prices merchants are willing to pay, stocks of that material must be very low.

THE SOCIETY OF ENGINEERS (INCORPORATED).—At the meeting of the Society of Engineers (Incorporated), held on February 7, the premiums awarded by the Council for papers read before the Society during 1915 were presented by the retiring President, Mr. Norman Scorgie, M. Inst. C.E., as follows:—The President's Gold Medal to Mr. Arthur H. Barker, B.A., B.Sc., for his paper on "Future Developments in Heating and Ventilation." The Bessemer Premium, value 5*l.* 5s., to Mr. Alphonse Steiger for his paper on "The Modern Development of Water Power." A Society's Premium, value 3*l.* 3s., to Mr. Sydney G. Turner, A.M. Inst. C.E., barrister-at-law, for his paper entitled "Law and Engineering—Some Points of Contact." A Society's Premium, value 2*l.* 2s., to Mr. Frank Grove for his paper on "Main Roads—Past and Present." Mr. Percy Griffith, M. Inst. C.E., F.G.S., F.R.San. I., President for the year 1916, was then invested with the badge of office, and delivered his presidential address.

ROYAL NAVY: SPECIAL ENTRY NAVAL CADETSHIPS.—Ninety cadetships (Special Entry) will be offered for competition at the examination to be held by the Civil Service Commissioners, conjointly with the Army Entrance Examination for Woolwich and Sandhurst, commencing on June 27 next. Candidates are required to be not more than 18½ nor less than 17½ on June 1, 1916. Candidates who have served with His Majesty's Naval or Military Forces during the war will be allowed a deduction from actual age in respect of such service. To receive this concession, candidates must furnish an official certificate as to the period of their service. The syllabus of subjects of examination and further particulars may be obtained from the Secretary of the Admiralty, Whitehall, S.W. Forms of application, to be filled in by the parents or guardians of candidates, will be furnished on application by letter addressed to the Secretary of the Admiralty. The forms should be completed and returned to the Secretary of the Admiralty not later than April 1.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—A not unexpected check has occurred in the rise in Cleveland pig-iron, and as a consequence the market has become unsettled. For a fortnight past values have uninterruptedly advanced, sometimes rather rapidly. The upward movement has been very largely due to the operations of outside speculators in warrants, whose manipulations are also responsible for the present unsteady state of the market. With quotations so uncertain from day to day, genuine business is curtailed, legitimate traders being unwilling to commit themselves ahead, and the business now passing is confined almost entirely to transactions for early delivery. This week No. 3 g.m.b. Cleveland pig has changed hands at 90s., and up to 93s. 9d. has been generally quoted. The market rate is now 93s. 6d. It is very difficult to fix quotations for other qualities of Cleveland iron. The usual proportions do not prevail, and each seller quotes according to how he is situated. With the single exception of forge iron, which is quite plentiful, all descriptions of Cleveland pig are very scarce. No. 1 may be quoted 97s. to 97s. 6d.; No. 4 foundry, round about 92s. 6d.; No. 4 forge, not more than 91s. 6d.; and mottled and white iron, each about 91s.

Hematite Iron.—There is very little new to report concerning the East Coast hematite branch of the staple industry. The iron now available for sale for supply during the first half of the year is practically nil, and many makers are not disposed to commit themselves beyond June, with the result that business is on a very limited scale. There are, however, continued good inquiries on forward account, and the recognised market quotation for Nos. 1, 2, and 3 is 140s. At the same time, contracts have been made this week at 137s. 6d. for July delivery. Further buying on behalf of France and Italy is looked for.

Blast-furnaces in Operation.—One of the furnaces at the Redcar Iron Works, which have been idle for some time past, has been put into operation on hematite iron, and at the Clarence works of Messrs. Bell Brothers a furnace is being blown in on Cleveland iron to replace one transferred some time ago on to hematite. These additions make the total number of furnaces in blast in this district 69, of which 28 are making Cleveland pig, 28 are producing hematite, and 13 are manufacturing special kinds of iron.

Stocks and Shipments of Pig-Iron.—Makers of pig-iron are all but denuded of stock, and the shortage is such that the iron in the public warrant stores is being drawn upon daily to assist in satisfying current needs. After a very lengthy absence, standard iron has reappeared in the warrant stores, 737 tons having, so far, been put into stock, which, with the 90,789 tons of No. 3, makes the total 91,526 tons. So far this month the stock has been reduced by 4328 tons. Shipments of pig-iron from the port of Middlesbrough to date this month amount to 1829 tons, as compared with 5962 tons to the same date last month, and 4565 tons for the corresponding part of February a year ago.

Coke.—Manufacturers of coke are complaining considerably that under the present conditions the fixed maximum price for home consumption is much too low. Business, however, continues to be put through at the 28s. maximum agreed upon for average blast-furnace kinds at the ovens.

Foreign Ore.—Though quite inactive, foreign ore keeps steady and firm. Consumers are now carrying large stocks, and with heavy supplies still arriving they are not in the market to buy. Sellers, on the other hand, intimate that they are not particularly necessitated to press business, and they are not disposed to make concessions. Market rates remain on the basis of 40s. ex-ship Tees for Rubio of 50 per cent. quality. Freights Bilbao-Middlesbrough are 23s. Imports of foreign ore to the Tees to date this month amount to 31,557 tons.

Manufactured Iron and Steel.—So far as is ascertainable there is no new development in the finished iron and steel industries. Manufacturers continue too busily employed on Government work to pay much attention to ordinary commercial business. The following are among the principal market quotations:—Common iron bars, 13*l.* 10s.; best bars, 13*l.* 17s. 6d.; best best bars, 14*l.* 5s.; packing iron (parallel), 9*l.* 10s.; packing iron (tapered), 11*l.* 10s.; iron ship plates, 11*l.* 10s.; iron ship-angles, 13*l.* 10s.; iron ship-rivets, 15*l.* 10s.; steel ship-plates, 11*l.* 10s.; steel ship-angles, 11*l.* 2s. 6d.; steel joists, 11*l.* 2s. 6d.; steel sheets (singles), 13*l.*; steel sheets (doubles), 15*l.*; and heavy steel rails, 10*l.* 17s. 6d.—rails net f.o.b., steel shipbuilding material and joists not at works, and all other descriptions less 2½ per cent. discount.

THE BRITISH JOURNAL PHOTOGRAPHIC ALMANAC.—We are pleased to notice the appearance of this, the fifty-fifth annual edition, for the year 1916, although it is somewhat shorn of its former grandeur of size. It still contains hosts of facts and formulæ which have been brought up to date, and a series of articles dealing with the principal printing processes, which will prove invaluable to all interested in photography. A new feature, in the shape of a review of the resources of British firms for the manufacture of all photographic apparatus, has been introduced, so that this volume, with its 1000 pages of notes and advertisements, should, indeed, form the "photographer's daily companion." Its price is 1s. in paper and 2s. in a cloth cover.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has shown little change, the general condition being one of continued strength. Colliery-owners, who are heavily booked both on Government and general export account, have been declining in many cases to enter into fresh commitments. Quotations have been nominally unaltered, but occasional sales of odd parcels have been reported at a substantial premium. Smalls have ruled firm. The best Admiralty large has been, to some extent, nominal; secondary qualities have made 34s. to 35s.; best bunker smalls, 19s. to 19s. 6d.; and cargo smalls, 12s. to 15s. per ton. The best household coal has brought 23s. to 24s. per ton. Other quotations have been:—Good households, 21s. to 22s.; No. 2 Rhondda large, 29s. to 31s.; and No. 2 smalls, 16s. to 17s. per ton. The latest quotation for patent fuel has been 30s. to 32s. per ton. Special foundry coke has realised 46s. to 47s. 6d.; good foundry coke, 40s. to 45s.; and furnace coke, 32s. to 36s. per ton. As regards iron ore, Rubio has brought 37s. to 39s. per ton upon a basis of 50 per cent. of nominal charges, including freight, insurance, &c., to Cardiff or Newport.

The Ebbw Vale.—The Ebbw Vale Steel, Iron and Coal Company, Limited, has made extensive purchases of land and minerals in an area extending from Irthlingborough to Finedon, in East Northamptonshire. The erection of 200 workmen's dwellings is in contemplation, and there will be a great development of the Northamptonshire iron industry. Calcining kilns are to be erected at Irthlingborough, and the output is to be transported thence to Ebbw Vale. Irthlingborough is on the Northampton and Peterborough branch of the London and North-Western system.

Western Trade Matters.—The revenue of the Newport Gas Company for 1915 was 48,429*l.*, of which 34,416*l.* was derived from the sale of gas and 9662*l.* from residual products; the working expenses of the year were 39,968*l.*; a statutory dividend of 5 per cent. is to be paid for the twelve months.—The Marquis of Bute has accepted an invitation to join the board of the Rhymney Railway Company.—The Swansea Gas Light Company, acting under instructions from the Ministry of Munitions, has been producing and recovering toluol and benzol, which are ingredients in the manufacture of modern high explosives.—In consequence of the increased cost of raw materials, the directors of the Swansea Company regret the probability of a further temporary increase in the price of gas. A statutory dividend of 5 per cent. per annum has been declared.—Notwithstanding a good demand for tin-plates, manufacturers have shown little disposition to book for any period ahead; it is estimated that about 70 per cent. of the current output is being absorbed by the Government and the Allies.—The Globe Shipping Company, Limited, will give its shareholders a dividend of 22½ per cent. for the past year. The company's steamers stand in the books at 96,626*l.*, or about 8*l.* per ton.—About twelve Greek steamers, exceeding 1500 tons net register, have been notified that their services are required by the Greek Government, and their captains are required to take orders from Greek consular officials.—The British authorities have agreed to permit the shipment of 50,000 tons of Welsh steam coal for Greece as soon as such a quantity can be spared, and as soon as licences for its shipment can be arranged.—A fall of 18s. 6d. per ton is reported in freights from Cardiff for Naples; a fall of 6s. per ton is also reported in the rate for Marseilles. On the other hand, freights have been supported for the Upper Mediterranean, and rates for South America have shown a tendency to advance.—The directors of the Cardiff Gas Light and Coke Company report that they have been compelled to advance the price of the company's gas 4d. per 1000 cubic feet.—The accounts of the Mumbles Railway and Pier Company show a balance of 5624*l.* available for dividend for the past year; the ordinary shares will receive 7½ per cent. per annum for the half-year ended December 31, 1294*l.* being carried forward.—The Port Talbot Dock and Railway Company maintains its dividend upon its ordinary stocks at 9 per cent. per annum, which has been the rate of distribution since the first half of 1913, and which is guaranteed by the Great Western Company.—The directors of the Consolidated Cambrian, Limited, of which Lord Rhondda is the master-spirit, have announced a dividend and bonus for 1915 at the rate of 15 per cent. per annum. The company owns the collieries forming the Cambrian Combine—viz., the Cambrian Collieries, Limited, the Glamorgan Coal Company, Limited, the Naval Colliery (1897), Limited, and the Britannic Merthyr Coal Company, Limited. It has been known for some time that the combine was doing exceedingly well.—The directors of the Barry Railway Company recommend a dividend at the rate of 9½ per cent. per annum for the second half of 1915. The dividends for the five years ending with 1915, inclusive, have been as follow:—1911, 6½ per cent. per annum; 1912, 7 per cent. per annum; 1913, 10 per cent. per annum; and 1914 and 1915, 9½ per cent. per annum.

THE DAVIS CAST-STEEL WHEEL.—The steel-tyred wheel and the rolled-steel wheel are known in the United States as "multiple-wear wheels"—i.e., wheels which are turned down several times during their life before their full mileage is run. The Davis cast-steel wheel is a one-wear wheel; its tread and flange are of tough manganese steel which blends into a soft, low-carbon steel to form its plate and hub. The combination of manganese and low-carbon steel in the same casting is obtained by a patent process owned by American Steel Foundries, Chicago, in which process, it is stated, the mould is spun whilst being poured. It is claimed for the Davis wheel that it is in every way cheaper than a steel-tyred wheel.

THE EMPLOYMENT OF WOMEN ON MUNITIONS OF WAR.

(*For Description, see Page* 137.)

Fig. 1. Women Working Two Lathes Each on Roughing Cuts.

Fig. 2. Acetylene Welding.

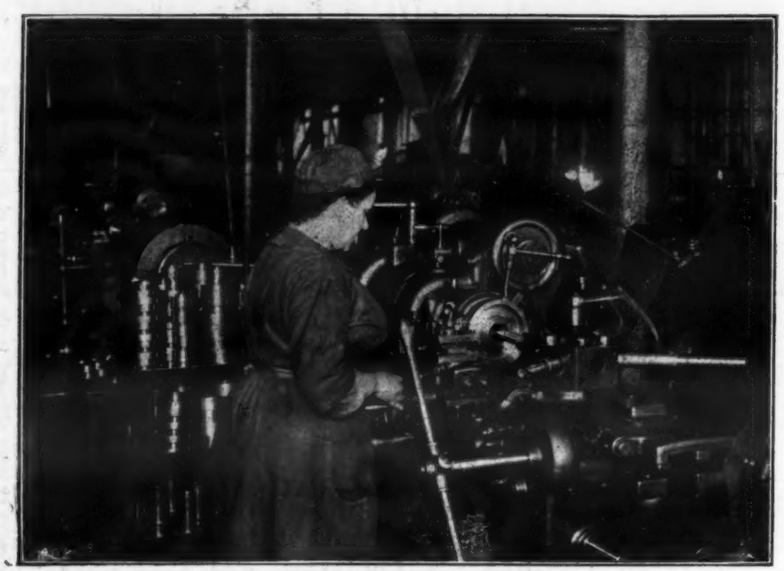


Fig. 3. Boring and Turning Wheel-Blanks.

Fig. 4. Women at Vice and Bench Work.

SPANISH TORPEDO-BOAT DESTROYERS

CONSTRUCTED BY THE SOCIEDAD ESPAÑOLA O

(For Descrip see P

Fig. 1

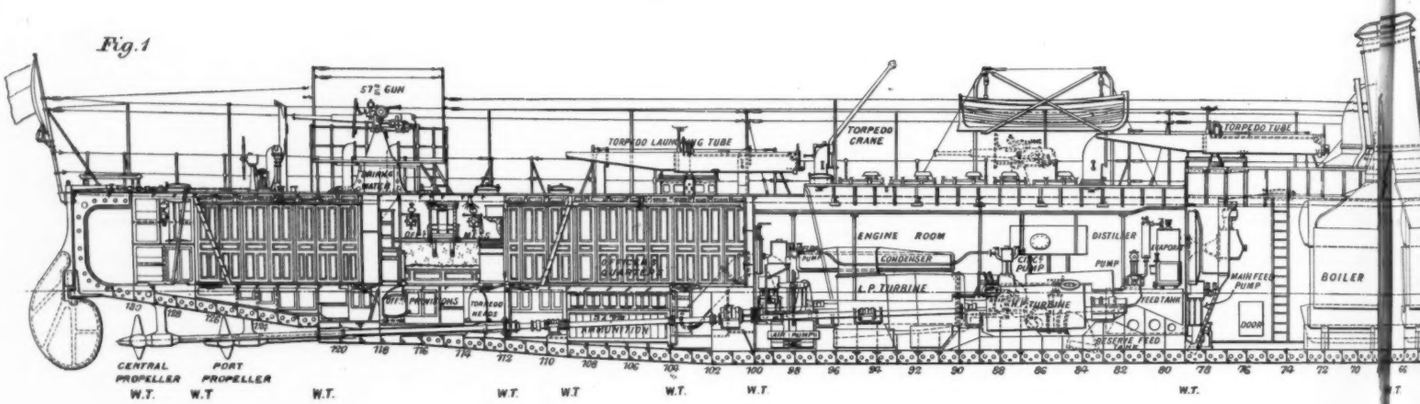


Fig. 2. UPPER DECK

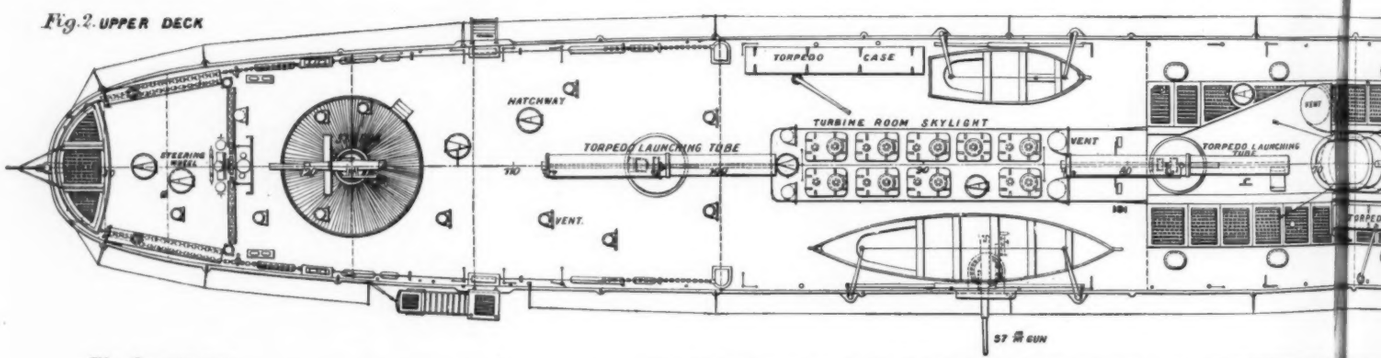


Fig. 3. LOWER DECK

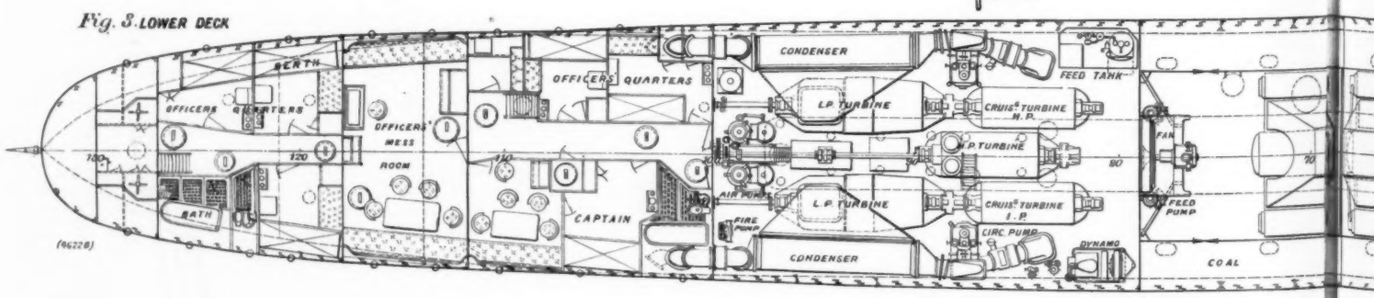
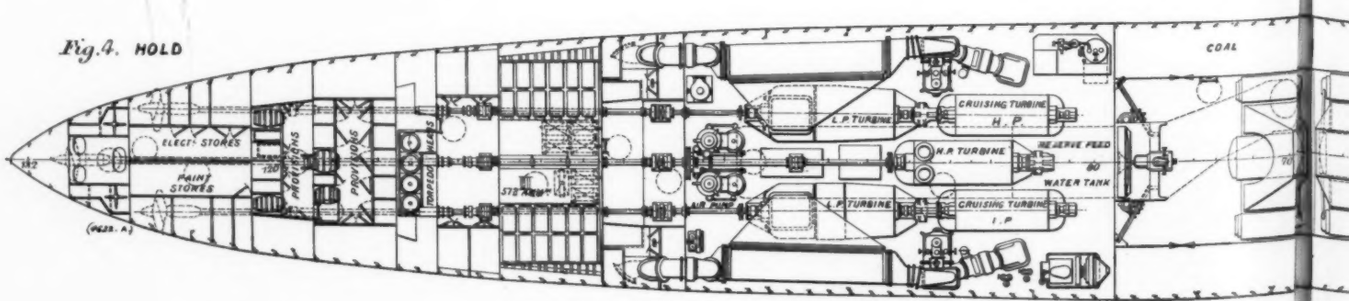


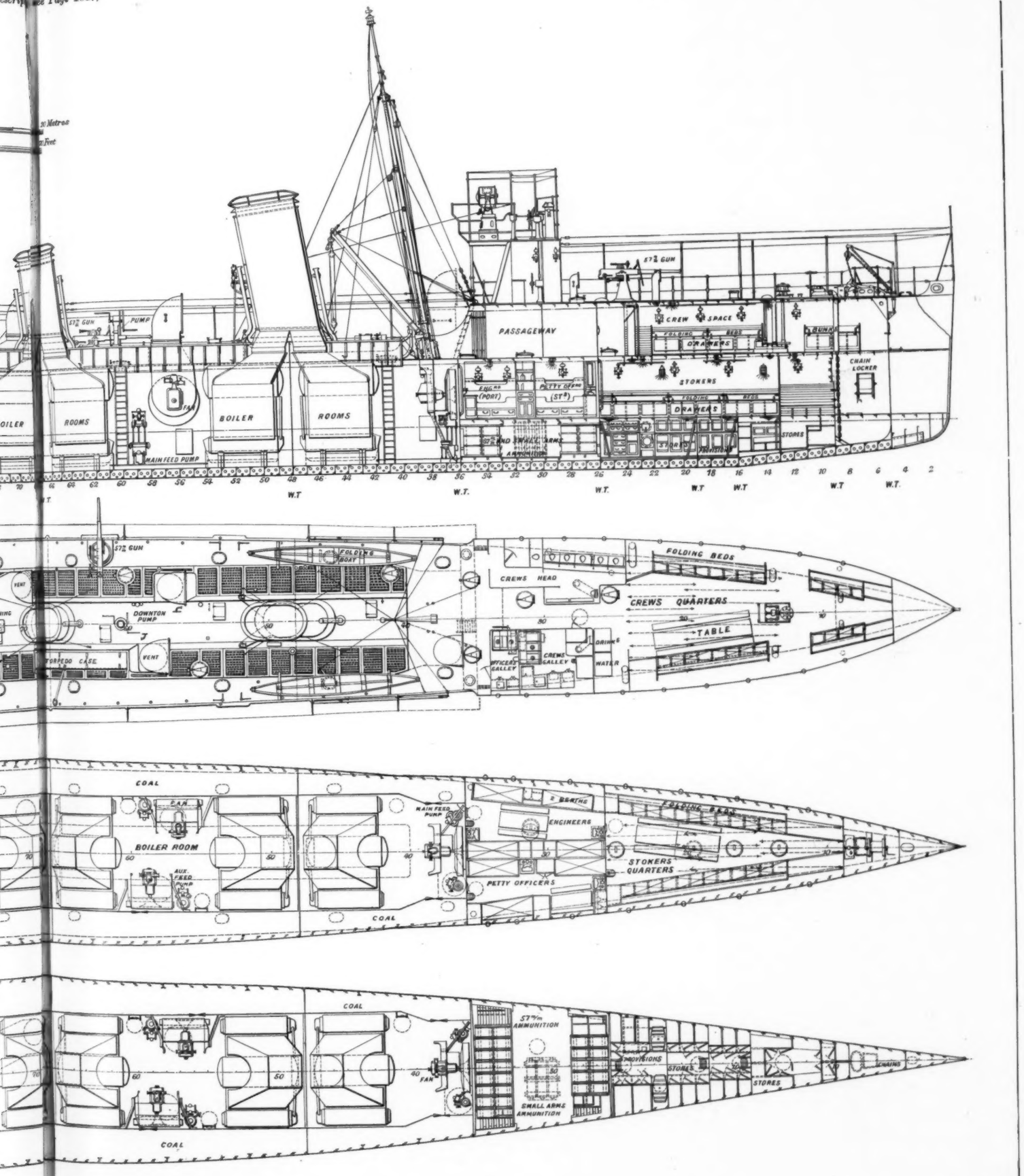
Fig. 4. HOLD



OYRS OF THE "BUSTAMANTE" CLASS.

NOLA[illegible] CONSTRUCCIÓN NAVAL, CARTAGENA, SPAIN.

escrip[illegible] see Page 131.)



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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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NOTICES OF MEETINGS.

THE PHYSICAL SOCIETY OF LONDON.—Friday, February 11, at 5 p.m., at the Imperial College of Science, Imperial Institute-road, South Kensington, S.W. Agenda: 1. "On a General Bridge Method for Comparing the Mutual Inductance between two Coils with the Self-Inductance of one of them," by Professor C. H. Lees, D.Sc., F.R.S. 2. "An Enclosed Cadmium-Vapour Arc Lamp," by Mr. H. J. S. Sand, D.Sc.

THE MINING INSTITUTE OF SCOTLAND.—Saturday, February 12, at 3 p.m., in the Heriot Watt College, Chambers-street, Edinburgh. Mr. Sam Mavor's paper on "Compressed Air for Coal-Cutters" will be discussed. Mr. James Black's paper on "Forming a Shaft Pillar in Thin Seams" will be discussed. Mr. Henry Briggs will read a paper on "A Device for the Rapid Estimation of Oxygen and Blackdamp in Mines."

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, February 12, at 2 p.m., in the Wood Memorial Hall, Newcastle-upon-Tyne. The following papers will be open for discussion:—"A New Battery Signalling Bell," by Professor W. M. Thornton. "Modern American Coal-Mining Methods, with Some Comparisons," by Mr. Samuel Dean. The following papers will be read or taken as read:—"The Hirsch Portable Electric Lamp," by Mr. Hiram H. Hirsch. "The Logic of Trams," by Mr. John Gibson. A Widdas patent incline chock will be exhibited, described and demonstrated by Mr. Percy Widdas. A safety mine-cage arrester will be exhibited, described and demonstrated by Mr. Thomas Pearson.

THE ROYAL SOCIETY OF ARTS.—Monday, February 14, at 4.30 p.m. Fothergill Lecture. "National and Historic Buildings in the War Zone; Their Beauty and their Ruin," by the Rev. George Herbert West, D.D., A.R.I.B.A., author of "Gothic Architecture in England and France" (Lecture II.). Wednesday, February 16, at 4.30 p.m. "Paper Supplies as Affected by the War," by Mr. S. Charles Phillips, M.S.C.I. The Right Hon. Lord Burnham will preside. Thursday, February 17, at 4.30 p.m. Indian Section. "The Saints of Pandharpur: the Dawn of the Maratha Power," by Mr. C. A. Kincaid, C.V.O., Indian Civil Service, author of "Deccan Nursery Tales." "The Indian Heroes," &c. Lieutenant-Colonel Sir David W. K. Barr, K.C.S.I., will preside.

THE INSTITUTION OF POST-OFFICE ELECTRICAL ENGINEERS (LONDON CENTRE).—Monday, February 14, at 6 p.m., at the Institution of Electrical Engineers, a paper will be read by Mr. J. Hedley on "The Western Electric Company's Semi-Automatic Telephone System."

THE CLEVELAND INSTITUTION OF ENGINEERS.—Monday, February 14, at 7.30 p.m., a Conversazione will be held in the Hall of the Literary and Philosophical Society, Corporation-road, Middlesbrough. Dr. J. E. Stead will deliver a lecture on "The Heat Treatment of Steel," illustrated with lantern-slides. Mr. C. H. Ridsdale will show a few lantern-slides illustrating electrical conductor rail-testing and electrical schemes now existing.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday February 15, at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. The following paper will be read:—"Oil Shales, Especially those of Dorsetshire," by Mr. W. Hardy Manfield.

THE CONCRETE INSTITUTE.—Wednesday, February 16, at 5.30 p.m., at 296, Vauxhall Bridge-road. Paper by Mr. Charles F. Marsh, M. Inst. C.E., entitled "Reinforced Concrete as Applied to Water Works Construction."

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, February 16, at 7.30 p.m., at 70, Victoria street, Westminster. Papers to be read:—1. "On the Rainfall of Nigeria and the Gold Coast," by Mr. C. E. P. Brooks, B.Sc., F.R. Met. Soc. 2. "South African Coast Temperatures," by Mr. J. R. Sutton, D.Sc., Hon. Mem. R. Met. Soc.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, February 17, at 8 p.m. The seventh Kelvin lecture, "Terrestrial Magnetism," by Dr. C. Chree, F.R.S.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, February 18, at the Institution of Civil Engineers, Great George-street, Westminster, at 6 p.m. Annual general meeting. The annual report of the council will be read. Subject of paper: "Chisels," by Mr. Henry Fowler, Member, Derby.

BRITISH FOUNDRYMEN'S ASSOCIATION: SHEFFIELD AND DISTRICT BRANCH.—Friday, February 18, at the Cutlers' Hall, Church-street, Sheffield, at 8 p.m., when a lecture will be given by Mr. J. T. Goodwin, of Sheepbridge, on "Foundry Practice" (illustrated by lantern-slides), to be followed by a discussion.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, February 18, at 5.30 p.m., a discourse will be delivered by Professor Ernest G. Coker, M.A., D.Sc. The subject is "Polarised Light and its Applications to Engineering." Afternoon lectures next week at 3 o'clock. Tuesday, February 15. Professor Charles S. Sherrington, M.D., LL.D., D.Sc., F.R.S., Fullerian Professor of Physiology, R.I., on "Nerve Tone and Posture" (Lecture V.). Thursday, February 17. Sir Frank Watson Dyson, M.A., LL.D., F.R.S., the Astronomer Royal, on "Measurement of the Brightness of Stars; Variable Stars" (Lecture II.). Saturday, February 19. Hon. John William Fortescue, M.V.O., Librarian, Windsor Castle, on "Eminent Generals of the Last Great War; Sir Ralph Abercromby and Sir Charles Stuart" (Lecture I.).

ENGINEERING.

FRIDAY, FEBRUARY 11, 1916.

THE ORGANISATION OF SCIENTIFIC RESEARCH.

OUR Government which, a few years ago, was with difficulty persuaded to grant a few thousands annually towards the establishment and upkeep of the National Physical Laboratory, is now credited with the intention of providing a million sterling a year for scientific research. We suppose the politicians imagine that money will solve the problem of our industrial inefficiency in many branches, and that henceforth all will be well. Money undoubtedly is essential to the progress of science and manufacture, but it is only one factor, and in a rich country it is the one most easily attained. At the commencement of the war Parliament voted supplies with a lavish hand, but the difficulties of creating and equipping an army reckoned in millions are not yet fully solved in spite of our spending five millions sterling a day. Neither shall we be put on an industrial equality with Germany by spending a million a year on scientific research, unless the control of the research is put into the hands of those who know exactly what our needs are, and in what degree they can be met by greater knowledge of scientific principles. The co-operation of many minds will be needed for the elaboration of the best plan, and it is to be hoped that all classes will have the opportunity of putting forward their views before a final decision is made. Some time ago a White Paper was issued by the Board of Trade giving the outlines of a scheme, and a committee has been appointed, but it cannot be said that the ideas so far promulgated are very promising. We need to hear the views both of scientists and manufacturers, and on that account we welcome the paper read last Wednesday before the Royal Society of Arts, by Dr. J. A. Fleming, F.R.S., on "The Organisation of Scientific Research." Dr. Fleming is not only a teacher and a scientific man of great reputation, but he has for long been associated with the practical side of wireless telegraphy, which is not only a commercial enterprise, but one that has fought its way into prominence in the face of a very strong competition.

Naturally, Dr. Fleming first dealt with organisation. He pointed out that the great amount of research work carried on here is done in a haphazard fashion. Each man takes up just what attracts him, and when it is completed he embodies the result in a paper, which eventually finds its way into the Transactions of some society, in company with many other papers to which it has no relation. Such papers are spontaneous efforts; they are not directed to the same end, and are neither complementary nor supplementary to each other. Under a system of State-aided research, such proceedings could not be tolerated. Those occupied in research must have their efforts directed by a body which might be compared with the general staff of an army, and which would concern itself with what Dr. Fleming calls "the strategy of scientific research." In this matter our scientific and technical societies could give great assistance, if they were asked, each in its own sphere, to take oversight of one branch of research, suggesting the objects, and finding opportunities for discussion as the matter proceeded. Already this has been done for over thirty years past, as far as financial resources would allow, by the Institution of Mechanical Engineers, while the Faraday Society has recently tackled the matter in a different way by obtaining a number of papers on a given subject, each dealing with one or more aspects of it, and discussing them together. In these cases the subjects of research and discussion were chosen by the Councils, who are men actively engaged in the application of the science or industries which the societies represent, and who therefore know the limitations of our present knowledge, and the points on which further enlightenment will be of most immediate value. Dr. Fleming hopes to see the leading members of the various existing chemical and engineering societies formed into permanent advisory committees, to lay down the lines of research in each subject, and to keep control of the operations.

It must not be assumed that all the research that is being carried on is being done in universities and colleges. A great deal is being done in works, and is never published, since those who pay for it naturally want to keep it to themselves. The results often lack the thoroughness of those attained in academic laboratories, since they are usually directed to some particular end, and do not deal with broad issues. A difficulty is experienced in manufacture, and a chemist or metallurgist is detailed to surmount it. The matter must be done as promptly as possible, and he has not the time to make broad generalisations. He discovers certain facts, and applies them to the subject in hand, and is satisfied. But a little further research would possibly enable the general law, of which the new knowledge is a particular instance, to be formulated, and a distinct step in science to be gained. In so far the works laboratory is inferior in its results. But the college laboratory also has its limitations. It elicits broad generalisations, but they are often so broad that they cannot be applied to any useful purpose. They are what Mr. Swinburne calls "raw science," and need much dressing to render them useful for commercial purposes. It will be the business of the directing body under the new scheme to combine both qualities in their researches, as far as it can be done.

Immediately scientific research is applied directly

to commercial ends the question of proprietorship intervenes. Is a discovery of immediate use the property of the discoverer, or of him that provides the necessary funds? This is a point that should be considered in advance, and definitely settled before any great scheme of Government-aided research is put into operation, otherwise we shall hear endless complaints on one side or the other. Dr. Fleming instanced one way in which the difficulty has already been met in the Universities of Kansas and Pittsburg. Those men who have graduated with distinction and exhibited capacity for original research are nominated Research Fellows. Manufacturers who are concerned with scientific processes are invited to state in strict confidence and in detail to the university certain particular difficulties or problems in their work which they wish solved. They then enter into a contract with the universities to pay for a defined time the stipend of a Research Fellow and certain fees, and to give a bonus or royalty to the investigator of the problem if satisfactorily solved. The Fellow, on his part, binds himself by contract to secrecy, and undertakes to apply for patents on behalf of his employers, and to certain other covenants. In this manner the interests of all parties are united.

The matter will not be so simple when the State finds the money. Are the results of researches to be published to all the world? and, if not, to whom are they to be communicated? It is said that the Badische Anilin und Soda Fabrik spent a million pounds and seventeen years' work in translating Baeyer's scientific synthesis of indigo into a factory process. This was not merely laboratory work; it also involved the creation of manufacturing processes by means of trial and error, and it would have been madness to publish the results as they were successively attained, to be taken up by others who had not shared the initial expenses. The research had to be done in secret all through, and when it was completed the manufacturers needed to be protected by patents in order to recoup themselves for the great expenditure. Many of those who cry out for scientific research have not contemplated anything of this kind. They have visions of laboratories filled with young men, each working at a bench a few feet long. But what is needed to put us on a level with our competitors in certain manufactures is a bridge to cover the gap between the inventor and the manufacturer. We have never been short of inventors, but often they have lacked the means or the opportunities to work out their discoveries. They have been deficient in workshop experience, and have been blind to commercial considerations. Our manufacturers, on the other hand, have allowed inventions to go abegging for want of scientific insight. They have failed to see what lay beneath the crudity of their appearance, and even when they have had some idea of the possibilities before them, they have felt that neither they, nor the inventor, had the necessary knowledge to translate the invention into a commercial process. What is needed is not merely scientific students, but men who, in the words of Dr. Fleming, have a "keen commercial sense which directs them to the solution of the practically useful problems." We have to create a much closer union between industry and science, and to do this we have not only to make our commercial men more scientific, but our technical men more cognisant of commercial conditions. The directing authority under the new scheme of scientific research will need to keep themselves in constant touch with the best representatives of our various manufacturing industries, and to learn from them not only the matters which need research, but also as to the way in which the research must be conducted to render it of practical service.

LEGAL LIMITATIONS IN ENGINEER WORKERS' AGREEMENTS.

A case of the fullest importance for engineers, whether employers or workers, was decided in the House of Lords on Tuesday last, involving, as it did, the question as to how far a covenant or agreement for service between an employer and a worker could limit action in seeking employment by the worker after he had left the employer's service.

The facts of the case are easily stated. The worker in this case entered into the employment of a firm who made a speciality of such forms of machinery as pulley-blocks, hand and electric overhead runways, and hand overhead travelling cranes. He served first as a junior draughtsman, from 1901, being then fifteen or sixteen years of age. When he came of age he was appointed leading draughtsman. At this time he was required to sign an agreement to the effect that, after leaving the employment of the company, he would not, for a period of seven years from the date of his ceasing to be employed, carry on "either as principal, agent, servant, or otherwise, alone or jointly, or in connection with any other person, firm, or company, or be concerned or assist, directly or indirectly, whether for reward or otherwise, in the sale or manufacture of pulley-blocks, hand overhead runways, electric overhead runways, hand overhead travelling cranes, or any part thereof, or be concerned or assist as aforesaid in any business connected with such sale and manufacture." The young man steadily advanced in the employment of the company, and was for a time in the London branch, to take part in sales, ultimately being manager of the branch; still later he returned to the works to take charge of the selling department there. In April, 1913, he left the service of the company. He first got employment with the French agents of the company, but, finally, realising that he could not secure the position to which his abilities entitled him as a general engineer, he entered the service of a Manchester firm who were the principal competitors of his original employers. The latter therefore raised an action for an injunction against their former employee because he had contravened the clause of his agreement with them from which we have already quoted. Mr. Justice Sargant, in the lower Court, decided against the company, as the enforcement of the clause would deprive the worker and the public of the benefit of the skill and experience which he had acquired while in the company's employment, and would prohibit him from using knowledge which formed part of his mental equipment. The Court of Appeal confirmed this judgment, and now the House of Lords have, in turn, dismissed the appeal of the original employers.

Lord Atkinson, who delivered the leading judgment, clearly defined the difference in a covenant in restraint of trade, as exacted by the purchaser of the goodwill of a business from the vendor, and a covenant between a master and a servant. He quoted the judgment of Lord Macnaghten, in 1894, remarking that it was laid down "in the clearest and most happily selected language." The passage was: "The true view at the present time is, I think, this. The public have an interest in everybody carrying on his trade freely; so has the individual. All interference with individual liberty of action in trading, and all restraints of trade of themselves, if there was nothing more, are contrary to public policy, and therefore void; that is the general rule. But there are exceptions; restraints of trade and interference with individual liberty of action may be justified by the special circumstances of a particular case. It is a sufficient justification, and, indeed, it is the only justification if the restriction is reasonable—reasonable, that is, in reference to the interests of the parties concerned, and reasonable in reference to the interests of the public, so framed and so guarded as to impose adequate protection to the party in whose favour it is imposed, while at the same time it is in no way injurious to the public. That, I think, is the fair result of all the authorities." Lord Atkinson pointed to the distinction drawn between "parties concerned," in the earlier portion of the passage, involving the covenanter and covenantee, while in the latter part of the passage there was reference to protection to the covenantee, which did not injure the public. In the case of a covenant between a vendor and a purchaser, where the restrictions imposed on the former enhanced the value of the good will and consequently the price paid, such restrictions on trade were permissible, in order to protect property. But in the case of a covenant between an employer and an employee the conditions were different. The employer was entitled to have his interest in his trade secrets protected, such as his secret processes of manufacture, by restraining the employee from divulging these secrets or putting them to his own use. He was also entitled not to have his old customers enticed away from him by solicitation. The freedom from all competition *per se*, apart from both these things, however lucrative it might be to him, he was not entitled to be protected against. In this case the company based their appeal on the plea that the respondent would carry away, and might put to use in the establishment of their trade rivals, the superior skill and knowledge which he had, by his talent, acquired at their works, raise the character of the output of the rivals, improve their methods, and thereby make them more formidable competitors in the trade of the appellants. Lord Atkinson accepted the view that it was doubtful if the employee, having specialised, could obtain employment as a general engineer, owing to his want of experience in engineering other than the one of which he had experience, so that he could only employ this skill and training to the most advantage, both to the community and himself, by engaging in that class of business in which he had passed his whole working life. He considered, therefore, that the maintenance of the covenant was prejudicial to the interests of the public.

Of the other agreeing judges, Lord Shaw of Dunfermline dealt similarly with the case, remarking that the firm based their case on the likelihood that the employee's own ability, skill, and knowledge would be of advantage to himself or others as competitors in manufacture or trade. This was "an audacious claim, whether regarded from the point of view of the parties or of the public." It was a claim against competition *per se*, a claim to cripple all rivals in trade by the denial to them of a supply of all skilled labour which had had the advantage of being performed under the appellants, and accordingly, *pro tanto*, to compel them to seek for labour in a foreign market. From the point of view of the worker, the claim amounted practically to exile for seven years of his life. From the point of view of society and of trade, it was in accord with public interest that our markets should be open and not shut to skilled labour and the commercial and industrial abilities of the inhabitants.

The other two agreeing Judges were Lord Parker of Waddington and Lord Sumner.

X RAYS, CRYSTAL STRUCTURE, AND CHEMISTRY.

The subject of the study of crystal structure by X-ray examination is so fascinating that one does not tire of reading of it, even if it advance very slowly. There is such a vast amount of material to be investigated, and so few are engaged in the investigation, for which even a stretched imagination can hardly anticipate any direct utility, that we must be satisfied if little progress appears to have been made within the last year. So far the chemist has hardly taken up any standpoint with regard to the new line of research, and Professor W. H. Bragg, F.R.S., of Leeds, was well advised to explain the principle of the matter when lecturing before the Chemical Society on February 3, on "Recent Work on X Rays and Crystals and its Bearing on Chemistry," rather than to give recent particulars, though that left him little time for the bearing of the subject on chemistry. Moreover, at present little more than tentative theoretical suggestions could be offered.

The origin of the line of research, Professor Bragg stated, was due to M. von Laue, to whom it occurred that a crystal should act as a diffraction grating when exposed to X rays. The method which Professor Bragg himself and his son, Mr. W. L. Bragg (who was also present), had subsequently developed, differed from Laue's, and seemed more convenient for quantitative measurements. If the material particles of a crystal were supposed to be arranged in parallel planes, like the leaves of a book, then homogeneous X rays entering the crystal would partly be reflected by each successive plane, there being more and more retardation of the wave as the ray penetrated through one, two, three, &c., planes. The reflected rays would therefore be in different phases, and interference would occur, as in a soap film, except that there were only an upper and a lower surface in the soap film, whilst there were many planes in the crystal. If rays of wave-length λ entered at an angle θ, and d were the spacings between successive planes, then a decided reflection would be noticed every time $n\,\lambda = 2\,d \sin\theta$, where n was an integer. When, therefore, the crystals were slowly turned, some weak reflection would always be noticed; but at certain positions or angles that reflection would become strong, and if the λ were known, then the d could be deduced. The rays experimented with came from anti-cathodes of palladium, rhodium, or platinum, &c., and the reflected rays were really the characteristic rays of these metals. From the work of Mosely and others it was known that each element gave two or four such rays (one or two

generally more prominent), and that, if the elements were arranged according to their atomic numbers, there was a regular slight shifting in the wave-lengths of the lines as we passed from one element to the other. It was fortunate for the new kind of research that the wave-lengths of the X rays and the spacings were approximately of the same order of magnitude; otherwise the study would be impossible; X rays of 0.614 Angström unit were much used. In the experiments the reflected X rays passed into an ionising-chamber containing generally methyl bromide, and the ionisation produced was measured. We have on other occasions described the X-ray spectrometer, by means of which the angles of the spectrum lines of different orders can be measured within a minute of arc.

Better to understand the significance of the planes, one might think of a wall-paper pattern. However complicated the pattern, one might take any point—say a rose—as centre and pass two systems of parallel lines through the roses, intersecting at any angles; the pattern would then appear to be cut up into units, and different systems of planes would give different units. Translated into solid geometry those lines became planes, forming by their intersections small cells or parallelopipeds, and the various unit cells, produced by passing systems of planes through different atoms, would not necessarily represent the outer form of the crystal. Even in a cubical crystal the spacings of those several systems of planes would have different values. To explain the relations, Professor Bragg exhibited many space-lattice models of crystals. In these, atoms are represented by beads fixed on wires; there may be, or may not be, a bead wherever two wires cross, and there may be other beads in between. The point is that each crystal is supposed to be built up of many unit crystals of its own type, which may grow in any direction—by making the wires longer or by adding more wires and beads to the model; matters become involved when one thinks only of one individual crystal. Thus, the lecturer showed, if one imagined a big cube, built up of a stack of small cubes, planes might be passed parallel to a face; or diagonally through the cube, through two opposite edges; or obliquely through the cube, through corresponding cubical diagonals of adjacent crystals. If the spacings between two successive planes were a in the first case, they would be $a\sqrt{2}$ in the second, and $a\sqrt{3}$ in the third. That could be seen in the projections of the space-lattices, produced by holding the model in the lantern beam, so that the rays fell normally on a face, or on an edge, or passed along a cubical diagonal. In other crystals the relations between the different spacings were less simple. The measurement of the angles of reflection of the X rays, however, always gave the spacings and the angles at which the planes of the unit cells intersected, but they did not show whether the beads (representative points) were all atoms of the same element, and whether there was one atom or a group of atoms in the respective planes and how they were distributed in a plane.

About those features, Professor Bragg proceeded, the intensity of the X-ray spectra gave information, and those peculiarities were best understood by reference to diffraction gratings. When all the rulings of a grating were equally fine, the intensity of the spectra of different orders would decrease in a regular way; when strong and faint lines alternated, the intensities of the spectra would alternate; and when certain lines were missing in the ruling, certain orders of the spectra would be missing. The intensity of the X-ray spectra depended similarly on the atomic mass of the atoms and on the presence or absence of the atoms in the respective planes. The example of potassium chloride (KCl) and sodium chloride (NaCl) was very instructive. The two salts were very similar to one another, they both crystallised in cubes, and yet their X-ray spectra differed strongly. In both the salts the metal (K or Na) and the chlorine atoms (Cl) might be supposed to be arranged in alternating parallel planes. But the atomic weights of K and Cl were nearly equal (39.1 and 35.5), whilst the atomic weights of Na and Cl (23 and 35.5) differed materially; hence the spectra intensities alternated in the latter case, and for further reasons it was assumed that in KCl the atoms occupied only the corners of the cubes, whilst in NaCl the centres of the faces were also occupied (face-centred crystals). All the measurements were relative only to start with. But the knowledge of the atomic weights of the constituents and of the densities of the crystals permitted of making absolute measurements. In the case of diamonds, the absence of certain spectra showed that the carbon atoms were so arranged that each atom formed the centre of a tetrahedron of the other four carbon atoms nearest to it, and that hence the atoms were arranged in planes spaced alternately at distances 1 and 3. Zincblende (ZnS) resembled diamonds in structure, though there were two kinds or atoms, of zinc and of sulphur. On the other hand, iron pyrites (FeS_2) had a more complicated structure; in that case a clue to the interpretation of the phenomena had been given by the fact that the cubical faces frequently bore parallel striations, parallel to one of the three cubical axes. Crystallographic analogy often afforded great help in these studies; it also brought out unexpected features. Thus the calcite ($CaCO_3$) rhombohedron was supposed to be symmetrical with regard to the line passing (in a section) through the two obtuse angles; but it was not exactly so, owing to the position of the oxygen atoms relative to the calcium and carbon atoms, and dolomite ($CaCO_3 . MgCO_3$) was not symmetrical at all, and could not be so. Magnesite, the iron oxide Fe_3O_4, was regarded as $FeO . Fe_2O_3$, containing both divalent and trivalent iron atoms, and Professor Bragg's model showed that some iron atoms appeared as centres of tetrahedron of oxygen atoms (4 O) about them, and some as centres of octahedra (6 O).

Coming to his general conclusions, Professor Bragg remarked that his representative points (beads) might represent more than one atom, and that the unit cell of an element might be complex; a sulphur crystal, *e.g.*, seemed to contain eight atoms. But he had spoken only of atoms; what became of the molecule? One atom of Cl did not seem to belong to one particular K atom next to it any more than to any other, in his models. Yet the molecule was not lost. When the K Cl model was taken to pieces, one K and one Cl would always go together, since there were only two kinds of alternating elements. But when complex models were similarly taken to pieces according to a certain plan, they would also fall naturally into molecular constituents, as he showed, though the molecule of the solid might not be the molecule of the gaseous and liquid states. The vibrations of the molecules became quicker in general, and the reflection less perfect, when bodies were heated. That should show in these experiments, and it had, indeed, been found that the lines of the spectra shifted, and that their intensities diminished when rock-salt was heated from 15 deg. to 370 deg. Cent. Such studies would thus teach something about molecular vibrations and their ranges. Mr. W. L. Bragg (now in the Army) was also studying the behaviour of allotropic modifications. The work was only in the beginning, and more workers were wanted.

The subject bristles with problems for the chemist, as Dr. A. Scott, President of the Chemical Society, remarked. On the other hand, we have to bear in mind that every new line of research brings up new difficulties, and that in their main features the views of Bragg and his collaborators harmonise with the views of Barlow and Pope on close packing in crystals, which themselves are based upon the teachings of early crystallographers.

WOMEN ON MUNITIONS WORK.

IT has long been known that on certain kinds of light machine-work female labour has proved highly satisfactory. Girls, for example, are largely employed in American watch factories, whilst in this country, on such light repetition work as is necessary in telephone manufacture, the introduction of female labour made it possible to compete with Sweden in the construction of these instruments.

Again, the invasion of American-made bicycles, which excited so much discussion some years ago, was repelled largely by replacing skilled male labour by women workers. Indeed, in some classes of work young girls and boys prove actually more effective than men. The latter, as their years increase, lose the nimbleness characteristic of youth, and it has been the experience of many firms that the output of certain machines was distinctly greater when operated by youths of either sex than when in charge of grown men. On certain varieties of repetition work the automatic machine can, in fact, be beaten for output by simpler tools operated by such youths.

The necessities of the time have enormously increased the scope of women's work in the field of mechanical engineering. In a very large class of operations they have proved both zealous and competent. There is in this no cause for astonishment. One hundred years or more ago the would-be fitter or turner served a seven years' apprenticeship, and considering the demands made on his personal skill and ingenuity, the time was by no means excessive. Large square-threaded screws, for example, were generated in the shops of Boulton and Watt by means of file and chisel. There would be some difficulty to-day in finding mechanics capable of such a feat. Nevertheless, the demand for skilled labour of the highest class is as great as ever, but it is not willingly devoted to tasks that can be satisfactorily effected by machines. There are, in fact, an enormous number of operations in a modern engineering shop which, though they would have taxed the highest skill available a hundred years ago, can now, thanks to improvements in machinery, be executed both more quickly and more accurately by labour which is not more than semi-skilled at the best. In America, for example, not merely in engineering, but in other departments of industry, an adequate supply of really skilled mechanics has never been forthcoming, and to economise this it was necessary to devise means by which the desired results could be achieved with untrained labour. The secret of success has consisted in subdividing the work as completely as possible, and in embodying in the machine the "thought" otherwise required from the workman.

A skilled turner is able to effect marvels with his lathe, and his ingenuity in clamping unhandy jobs on his face-plate shows that the pattern-maker is far from justified in his not infrequent boast that in his trade alone is the workman called upon to show personal ingenuity and resource. A long training is, however, necessary to produce the "compleat" turner; but it is a simple matter to train even a raw hand to carry out a single operation successfully, particularly if some thought is given to making it easy for him to mount the work ready for machining. There is an adage that razors should not be used for cleaving whetstones, and it can hardly be to the advantage of the community at large to employ men, whose training has required years of application, on work so simple that any intelligent labourer can learn to do it in the course of a few days. For some reason or other, however, the skilled hands have often claimed the privilege of doing this semi-skilled repetition work themselves; but where commonsense and economic considerations have proved bootless, patriotism has prevailed, and in very many districts of the country the restrictions by which unskilled operations had to be carried out by skilled men have been waived for the time being, and a beautifully illustrated volume* just issued by the Ministry of Munitions gives most interesting data as to the many fields in which women's work is now proving of the highest advantage to the nation.

On pages 134, 138, and 139 we reproduce, by permission, engravings from this book, which show that the women's work is confined neither to the simplest tasks of the machine-shop nor to the operation of the lightest class of tool. Indeed, the work illustrated in Figs. 1 to 4, page 134, is of a fairly advanced character, including, it will be seen, a certain amount of fitting. It should be observed in passing that none of the work in question is in the experimental stage, which has, in fact, been passed long since in every case illustrated.

In drilling shell bodies for 18-pounder shells, it is found that the women can run two machines each. The only change made in transferring this work from men to women was to supply a simpler means of gripping and holding the shell whilst being drilled. We reproduce from the book under review a photograph, Fig. 11, page 139, which shows the device used. With this aid the women have succeeded in getting the same output from the machines as the men they replaced. One man is, however, retained as supervisor for each eight machines. Every precaution is taken, of course, to facilitate the work and prevent errors, automatic cut-offs and stops being provided to prevent the possibility of mistakes. Again, in certain cases, the women are operating two lathes each (see Fig. 1,

* "Notes on the Employment of Women on Munitions of War. With an Appendix on the Training of Munition Workers." Issued by the Ministry of Munitions. Messrs. Wyman and Sons, Limited. [Price 1s.]

THE EMPLOYMENT OF WOMEN ON MUNITIONS OF WAR.

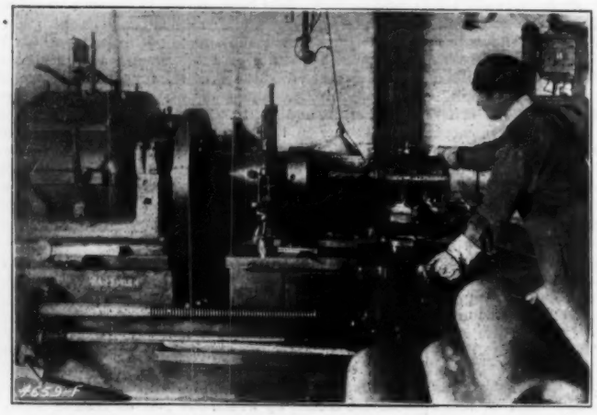


Fig. 5. Boring 6-In. Shells.

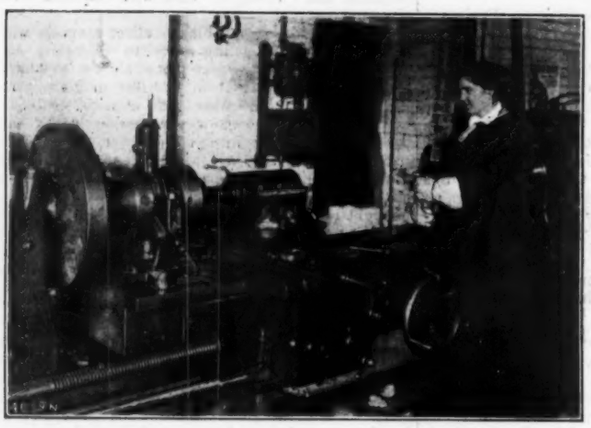


Fig. 6. "Bottoming" 6-In. Shells.

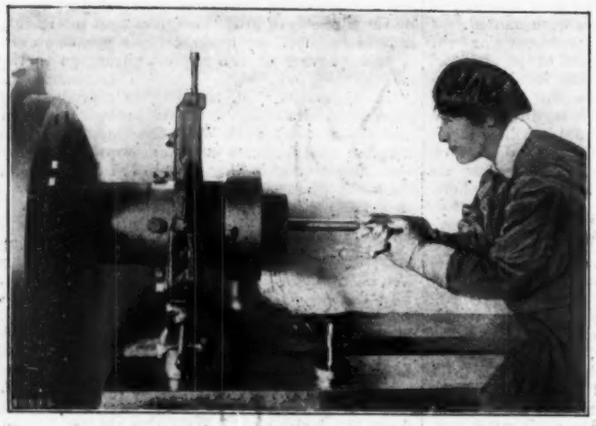


Fig. 7. Gauging 6-In. Shells.

Fig. 8. Milling Teeth and Pellet Holes on Time-Rings of Fuses.

Fig. 9. Heavy Turret-Lathe Work.

page 134). These lathes are used for roughing cuts only, the work, in accordance with the principle of subdivision already referred to, being finished on other lathes. In order to prevent delays for the regrinding and readjustment of tools, the machines are fitted with a special tool-post carrying a second tool, which is adjusted to a gauge, and can be brought into operation as soon as that in use gives out. This plan has been followed in many of the factories engaged in making munitions, and effects a substantial increase in the output.

In one shop staffed mainly by women the work consists of the complete machining of 4½-in. high-explosive shells, and three shifts are worked per 24 hours. Even the copper driving bands for the shells are machined by female labour, an operation in which a high standard of accuracy is required. Moreover, the women also press the bands into place and rivet the base plugs into high-explosive shell bodies. Here, again, the work is facilitated by the provision of special chucks for holding the shells. It has further been found that by providing adequate facilities for lifting, the women are quite capable of machining shells as much as 8 in. in diameter. Our illustrations, Figs. 5, 6, and 7, above, show a series of three operations on 6-in. shells. In this case, again, special apparatus has been provided to facilitate the work and to prevent the breakage of cutters, &c., by the unskilled hand. The operation of boring one of these shells is shown in Fig. 5. Power-feed is used for the straight portion of the bore, but in "bottoming," as in Fig. 6, the feed is applied by hand. In Fig. 7 the operator is shown testing the result with limit-gauges.

In the foregoing cases, by a somewhat minute subdivision of the work, each girl is required only to acquire the knack of executing one or two simple operations, but, as already mentioned, female labour

THE EMPLOYMENT OF WOMEN ON MUNITIONS OF WAR.

FIG. 10. WOMEN ENGAGED IN COVERING AEROPLANE WINGS.

is also being successfully used in ordinary machine-tool work. The plan followed is to arrange the labour in teams, each consisting of a man and a woman, who together operate two machines. Each of these machines was previously worked by a man. Under the new system the "team" takes the same amount in wages as the two men did aforetime, a larger share of the total going to the man, who is the responsible head. The class of work includes such operations as boring the hollow spindle of a lathe, and the making of milling-cutters. In Fig. 3, page 134, we reproduce photographs showing a woman engaged in the turning and boring of wheel blanks, whilst another engaged in accurate repetition work is represented in Fig. 9, page 138.

The activities of the women workers are not, however, confined to machine work. For instance, they are successfully assembling, gauging, and brazing turbine-blades, an operation which in some shops in the past has been confined to skilled hands, though in other establishments boy labour has been mainly used.

Acetylene welding is another operation which, as indicated in Fig. 2, has proved to be within the compass of women's powers. Much of this has, of course, been done by unskilled labour in the past, though some jobs will always require the services of a specialist. The view we reproduce in Fig. 10, above, showing the covering of aeroplane winge, is, perhaps, in one way less striking than the operations previously described, as women have long worked with textile materials.

We note, moreover, that most of the fuse factories are entirely manned by women. The operations are extremely numerous, and the fuses have to be handled again and again, so that very careful organisation is required. Fig. 8, page 138, gives some idea of the very large number of women employed in this class of work. It has further been found possible to use female labour in gauging and inspecting the finished products. To this end the work has been minutely subdivided, so that each girl has to learn to use one or two gauges only.

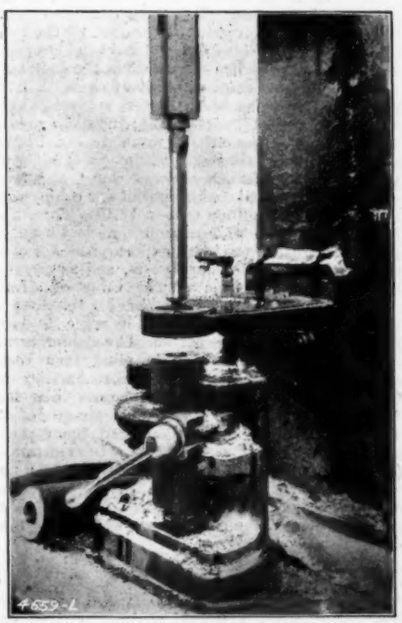


FIG. 11. CHUCK FOR HOLDING SHELLS FOR DRILLING.

The enormous increase in output effected by this dilution of labour has caused a dearth of tool-setters. These have hitherto been workmen of rather more than average intelligence, and it was difficult at first to supply the deficiency. To some extent this has been overcome by providing professional men, such as architects and the like (whose business has in many cases been ruined by the war) with a training in the work. As intelligence is the main factor required, many of these men have learnt very quickly all that was necessary for the operation of certain machines; whilst others with exceptional natural gifts have proved capable of going further, and have graduated as successful gauge-makers, in spite of the great delicacy of this class of work. Much of the training has been given in the workshops attached to the various technical schools. In some cases manufacturers have sent typical machines to the schools in question, so that the tool-setter may learn exactly the work for which his services are required. In most cases these "setters" have proved quite satisfactory, and have made possible the employment of thousands of hands who would not otherwise have been available. Being for the most part drawn from the professional classes, these tool-setters will no doubt revert to their previous occupations at the end of the war.

The national importance of this work on munitions cannot be over-estimated. All reports from the Front concur in emphasising the personal superiority of our soldiers over their opponents.

The latter had, however, last winter an enormous advantage in their supplies of guns and munitions generally, and yet in spite of this they were held up. Thanks to the adaptability and industry of our women, this adverse balance promises to be written off ere the coming summer; and once provided with adequate munitions, the natural superiority of our men will become a decisive factor, in spite of the industry which makes the German soldier particularly formidable in defence.

COAL ENERGY UTILISATION AND FUEL ECONOMY.

WHEN called to the chair of the Chemical Section of the British Association last autumn at Manchester, Professor W. A. Bone, F.R.S., chose fuel economy and the prevention of waste as the subject of his address. It was the subject in which he, as former chief of the fuel research laboratories at the University of Leeds, and now as chief Professor of Chemical Technology at the Imperial College of Science, South Kensington, is most directly interested, and the importance of which has long been admitted, though not fully appreciated, by chemists and engineers. To recognise the necessity of a change is not by any means tantamount to taking steps to enforce it, though manifold considerations, our comfort and health among them, may urge it; and as some manufacturers still do little to suppress waste, and the public remain the greatest sinners in wasting fuel and polluting the atmosphere, not realising the vast savings possible, Professor Bone re-opened his campaign at the Royal Institution, where he delivered lectures on the Thursdays of the past three weeks. As dealt with by Dr. Bone, the subject was too large for a detailed report. His object is to rouse the public and the Government to prepare for "the trying years of economic recuperation and the readjustment" which will follow the war.

In his opening remarks, Professor Bone emphasised that the question was a national one and could not be left to individual effort, though the rising prices of fuel would themselves tend to stop waste. Coal had not to be valued simply as a fuel; it also yielded the raw materials for dyes, many chemicals, high explosives, and ammonia; referring only to the latter, the total British production of ammonium salts amounted in 1912 to 379,000 tons, out of which 318,000 tons were derived from coal, whilst Germany produced 500,000 tons of those salts from a smaller coal output, and had saved some 2,000,000*l.*, thanks to their by-product coke-ovens. Passing to the origin and classification of coal, the lecturer gave the following table of compositions and calorific values in kg.-Centigrade units per kg. (K.C.U.):—

—	Carbon.	Hydrogen.	Oxygen or Nitrogen.	K.C.U
	per cent.	per cent.	per cent.	
Wood	50	6	44	4000 to 5000
Peat	50 to 64	4.5 to 6.8	28 to 44	5000 ,, 6000
Lignite	60 ,, 75	5	20 ,, 34	6000 ,, 7000
Bituminous coal ..	75 ,, 90	4.5 to 5.5	5.5 to 15.0	8000 ,, 9600
Anthracite	90 ,; 96	2.5	3	9200 ,, 9600

Little had been done, the lecturer said, to utilize the stores of peat and of lignite, the latter quite as important for Canada and Australia probably as for Austria and Germany. As regards classification, Grüner's classification still seemed the best for economic purposes. It was based in the first instance on the amount of volatile matter (given off by distillation between 900 deg. and 1000 deg. Cent.) and distinguished:—

I. Highly bituminous coal (over 40 per cent. of volatile matter, long-flamed, good for reverberatory furnaces, not for steam-raising and coking, the coke being pulverulent, 8000 to 8500 K.C.U.); II., long-flame coal (32 to 40 per cent. of volatiles, best gas-coal, porous coke); III. and IV., best coking coals (20 to 32 per cent. of volatiles, up to 78 per cent. of hard metallurgical coke, 8500 to 9300 K.C.U.); Va, a semi-bituminous coal (Admiralty steam coal, 14 to 20 per cent. of volatiles, 9000 to 9500 K.C.U.); and Vb, anthracitic hard steam coal (8 to 14 per cent. of volatiles, 82 to 92 per cent. of pulverulent coke). Anthracites proper (below 8 per cent. of volatiles) might be distinguished as a sixth class; China seemed to possess most (80 per cent.) of the reserves of anthracite, next to Russia and Pennsylvania. The carbon percentage rose in the order stated from 75 to 93 per cent., the percentage of oxygen and nitrogen (together) diminished from 20 to 3 per cent., and the hydrogen percentage changed little throughout, ranging between 4 and 5.6 per cent. The coking properties obtained their maximum with 20 or 30 per cent. of volatiles, then to diminish. Until quite recently the development of all carboniferous coal had been considered to have been on fairly the same lines, from ferns or peat through lignite and bituminous coal to anthracite; but in South Wales the ash contents diminished as bituminous coal gradually changed into anthracite. That suggested different origins, and, according to the recent researches of Wheeler and others (to which we have referred), coal contained chiefly compounds of two types in different proportions:—(1) Unstable resinous constituents, decomposing between 400 deg. and 700 deg. Cent. into paraffin hydrocarbons, methane, and little hydrogen, and (2) degradation products of cellulose yielding above a certain temperature (700 deg. or 800 deg. Cent.) almost exclusively hydrogen; the resins absorbed oxygen from the air. According to Renault, cellulose $(C_6H_{10}O_5)x$ changed into coal, something like C_9H_6O. But we practically knew nothing about the real constitution of coal, and if anybody questioned that, he would ask him to tell how the percentage of benzene and toluene (wanted for making explosives) could be increased by some system of carbonisation. Professor Bone therefore pleaded for two things as a basis of the scientific utilisation of coal: Systematic chemical investigation of the nature of coal; and a chemical survey of the British coal-fields organised by a public department in conjunction with the fuel research laboratories of the country.

In the second lecture Professor Bone discussed the world's stores of coal and their value as national assets. According to the statistics compiled by the International Geological Congress of 1913, the total probable reserves of all coal (including lignite) within 6000 ft. of the surface of the earth amounted to 7,397,553 million metric tons, which was approximately 6000 times the present total annual consumption. Of these reserves, 6.75 per cent. were anthracite (80 per cent. located in China), 52.75 per cent. bituminous coal, and 40.5 per cent. sub-bituminous coal (including tertiary coal and lignites). Europe contained 10.ℓ per cent. of these stores; Asia, 17.3; China, 13.5; Oceania, 2.4; Africa, 0.6; and America, 69 per cent.; United States, 51.8; Canada, 13.5. Professor Bone preferred to place China next to the United States, and said that the coal of America and China was most significant for the future centres of industry. The world's consumption of coal had risen from 800 million tons in 1903 to 1250 million tons in 1913—*i.e.*, at an average compound interest rate of nearly 5 per cent. The three countries chiefly concerned in the output (83 per cent. of the total) were the United States, Great Britain and Germany, and their outputs had increased at the compound rate of 6, 2, 4 per cent. respectively since 1903. At present Germany's coal stores were more than twice as large as the British coal stores; but at the present rates of growth the outputs would be equal in the two countries (at about 420 million tons) in twenty years, and the future chances were thus fairly equal. The annual coal output of our country had risen from 121.5 million tons in 1870 to 270 million tons in 1913, and 97.7 million tons had been exported in 1913; the coal exports had increased twentyfold in the last sixty years, and represented at present 10 per cent. of the value of all the country's exports. That astounding increase in the coal exports was considered by some as alarming, by others as indispensable. In considering this question one had to bear in mind that Welsh steam coal was near the ports, that America and Germany mostly exported coal across their land frontiers, and that the phenomenal growth of the British mercantile marine depended upon profitable inward and outward cargoes. Inward cargoes (foodstuffs and raw materials) were bulky; outward cargoes (machinery and manufactured articles), except coal, mostly small in bulk; and maritime supremacy and large coal exports were hence interdependent.

In estimating the duration of the British coal supplies in particular, the minimum thickness of workable seams had been assumed as 1 ft., and the limit of practicable depth at 4000 ft.; at that depth an average temperature of 116 deg. Fahr. was supposed to prevail; the deepest mines in Great Britain extended to 3500 ft., in Belgium to 3773 ft. The estimated British coal reserves of the two Royal Commissions of 1871 and 1905, of A. Strahan of 1911, and of H. S. Jevons of 1915, were:—146,480, 141,635, 178,727, and 197,000 million tons respectively; the last figure was 580 times the present output. As regards coal consumption, G. Beilby estimated in 1903 that, of a total home consumption of 167 million tons, factories and mines absorbed 43 per cent.; iron and steel works, 17 per cent.; gas works, 9 per cent.; railways, 8 per cent.; and domestic furnaces, 20 per cent.; leaving 3 per cent. for glass and chemical works, potteries, &c. Roughly, those percentages would probably still hold. Economising depended upon the intended use of the coal, of course; but the barbarous custom of burning raw coal should altogether be abolished. Carbonisation at high temperature (gas works, coke-ovens) yielded for 100 parts of dry, ashless coal: 60 to 75 parts of coke, 3 5 to 5.5 of tar (benzenoid and phenolic), 5 to 10 of liquor, and 13 to 17 of gas, there being per ton, 10,000 to 12,000 cub. ft. of gas of 500 or 550 B.T.U. per cubic foot. Low-temperature carbonisation yielded 75 parts of semi-coke, 15 of crude oil, 5 of liquor, and 5 of gas. In 1913, 40 million tons of coal were carbonised, about half in gas works and half in coke-ovens, and of these latter 6.5 million tons were still treated in the wasteful bee-hive ovens, wasting the 20 lb. or 35 lb. of ammonium sulphate, 56 lb. or 112 lb. of tar, 2 or 3½ gallons of crude benzol, &c., and about 5000 cub. ft. of surplus gas that might have been recovered in by-product ovens, at a total saving of 2,250,000*l.* A time-limit should be fixed for the installation of bee-hive ovens.

In order to illustrate what modern by-product recovery means, Professor Bone exhibited photographs of a model plant, on the Otto direct-recovery system, from the North of England. One of the interesting features of this plant was that the gas, cooled to dew-point by traversing a long, horizontal pipe and an atmospheric cooler, passed to a tar-extracter worked on the injection principle, the hot gas being met by a high-pressure jet of hot tar and liquor, which was broken up into a spray, and took the tar in the gas down with it. Other features were the saturators, in which the gas was divided into many streams, entering hot sulphuric acid, and the benzol and naphthalene-scrubbers, towers up to 70 ft. in height.

As regards domestic fires, Professor Bone recommended gas fires, and drew attention to the peculiar fire-place of Professor Vernon Harcourt, mentioning a feature which Mr. Harcourt did not point out at Manchester (see ENGINEERING, vol. c., page 403, October 15, 1915). The coke is piled up in a column 2 ft. high, only 4 in. or 5 in. deep front to back, without a grid below, and lighted by wood and a few pieces of coal placed on top of the column; the air enters through the bars in front, and as the fire descends in the column, the shutters closing the space above the coke column up to the mantel-piece are gradually lowered; this is the essential feature not mentioned previously.

Dwelling, in the third lecture, on fuel economy in large power plants and in the iron and steel industries, Professor Bone pointed out that with a good average coal, giving 13,000 B.T.U. per pound, a horse-power hour should be available at an expenditure of ½ lb. of coal; but the average coal consumption from Beilby's estimate of 1903 was 5 lb. per horse-power hour. The coal energy could be converted into power either by means of raising steam for steam-engines or by gasifying the coal for internal-combustion engines. The best gas-engines had, in 1903, given 1 horse-power-hour, at full load, for 1 lb. of coal in the producer, whilst steam plants were far less efficient. The new 35,000-horse-power Parsons turbine in Chicago also worked at that coal figure, assuming, however, a boiler efficiency of 75 per cent. Thus there seemed little to choose between the two systems, though some years ago the gas-engine had appeared to be decidedly preferable on the whole. But the direct thermal efficiency of the conversion was frequently less important than the general planning and organisation of the plant. Gas-producers could use inferior coal, but had been expensive in plant when designed for ammonia recovery; that difficulty had now been overcome apparently in Mond plants. Going into particulars as to the various sources of loss, Professor Bone suggested the gasification of raw coal, to recover the ammonia (representing in value 30 per cent. of the coal), and the burning of the gas in his

surface-combustion boilers. In his multitubular waste-heat boilers, the exhaust gas from internal-combustion engines was passed through tubes packed with granular material. As regards size of unit, the steam-turbine was far ahead of its rivals; it also worked at relatively good efficiency with low loads; but for small units (up to 2000 horse-power), at fairly steady loads, the gas-engine had certain advantages. There were still many inefficient plants, however, which were better put on the scrap-heap, and the State might advance money for this purpose; some 20 million tons of coal were still wasted in power production.

In order to illustrate what could be achieved by the co-operation of consumers with a well-organised electric power company, Professor Bone gave an outline of the development of the North-East Coast Power Company, which had grown out of the combination of various concerns since 1900. The area covered the great northern coal and iron fields from Morpeth and Blyth to the Cleveland district, an area with 5 per cent. of the population of the United Kingdom, which in 1908 produced 20 per cent. of the total coal, 36.4 per cent. of the coke, 37.5 per cent. of the iron, and 36.5 per cent. of the country's shipping tonnage. The total generating power of the 17 power-stations was now 220,000 horse-power, the horse-power connected was 340,000; the power was derived from coal or gas fires, from blast-furnace and coke-ovens, and from waste heat, all the heat was turned into steam for turbines, and the electric energy was generated and distributed at various potentials up to 11,500 volts, but all three-phase at 40 cycles. As a contrast, Professor Bone pointed to London, where 65 authorities supplied electricity on 49 systems from 70 generating stations, some small, at 70 different rates and prices; to some of the stations the coal was still being carted.

The lecturer then passed to the public supply of gas for industrial purposes, in which respect Birmingham and Sheffield had taken a noteworthy lead, and mentioned that the South Staffordshire Mond Gas Company now distributed Mond gas of 140 B.Th.U. per cub. ft. over an industrial area of 123 square miles, selling it at 1¾d. per 1000 cub. ft., while high-pressure (12 lb.) gas at Birmingham cost from 11.4d. to 15.2d. Finally, Professor Bone exemplified, by referring to the Skinningrove Iron and Steel Works and other plants, the wonderful improvements and economies realised by the concentration of by-product coke-ovens, blast-furnaces, steel works, and rolling-mills in one plant, and by coupling the utilisation of the combined surplus of coke-oven gas and cleaned blast-furnace gas, partly to drive gas-engines and electric motors for the rolling-mills and other machinery, and partly to displace producer-gas as the fuel for the steel furnaces and soaking-pits, so that the iron-stone taken in passed out as finished-steel sections, no more coal being used than the coke-ovens required to supply the blast-furnaces with coke. That implied that 1.6 tons of coal, instead of 2.35 tons formerly, gave 1 ton of iron. The heat of the molten slag was not yet utilised.

Concluding, Professor Bone stated that the Royal Commission of 1905 had estimated the possible saving in the annual coal consumption at from 40 to 60 millions tons; the margin was probably not much less to-day, he thought.

NOTES.

Electric Switch Pillars.

The unfortunate accident at Eastbourne, on December 26, by which two persons lost their lives by the smashing of an electric switch pillar, has been investigated on behalf of the Board of Trade by Mr. A. P. Trotter, their electrical adviser. The facts are quite simple. By some means a large motor-car unaccountably swerved to the left and collided with an electric switch pillar, smashing it into fragments. This pillar measured 4 ft. by 2 ft. 2 in. by 1 ft. 9 in., and stood at the edge of the footpath, which had no curb. The passengers were not hurt, but two men who tried to move the car were killed by electric shock, while several others suffered slightly from the same cause. There is no exact evidence as to the contact made by the car with the electric conductors in the pillar, or with the pillar itself, but it is clear that good contact was made, while the car itself was insulated from the earth by the india-rubber tyres. This is evidenced by the fact that at the instant of the collision the oil-switch on the feeder at the works was tripped, but on being immediately replaced by the attendant it held in. The men who took hold of the car formed a connection to earth for the current, which was of 2000 volts alternating. Mr. Trotter evidently disapproves of electric pillar-boxes for high-pressure supply, but suggests that the danger can be very greatly reduced by building them into the walls of houses or gardens instead of placing them on the footpath. He recommends that in any case there should be a curb not less than 6 in. high, extending not less than 10 ft. on each side of the pillar. Where pillars are set near a curb, fenders or spurs of stone or cast iron could be usefully set at the corners of the pillars facing the road. Cast-iron pillars should be reinforced by a cage of wrought-iron rods incorporated in or attached to the cast iron, or an inner lining of sheet or expanded metal should be attached to the pillar and the doors, and the pillar should be connected to a substantial earthplate, as well as to the lead of the cables. There should be no loose insulated wires in the pillars, and if such wires must be used they should be enclosed in metal tubes carefully earthed and filled in solid with compound. If these precautions were taken it is difficult to see how an accident of this kind could occur again.

Replacement of Early Turbines in the United States Navy.

It is of interest to note that some of the early Curtis experimental turbines are to be removed from certain American war vessels, including the battleship North Dakota, the scout-cruiser Salem, and the destroyer Henley, while Zoelly turbines are being superseded in the destroyer Mayrant. This is not surprising, since most of the turbines in question were designed and installed when comparatively little practical knowledge of the peculiarities of the velocity-compounded machine was available. The early workers on the impulse turbine, whether velocity-compounded or not, were unduly sanguine as to the advantages of the type. One very well-known Continental engineer maintained in those days that, whilst the Parsons type might do very well in land work, it would soon be superseded at sea, because he claimed that it would be cheaper to construct a slow-speed simple impulse turbine than a reaction turbine of the same efficiency. Experience has proved the contrary, though in high-speed machines of fairly large output the impulse turbine holds its own. Many of these Continental engineers failed to understand the full significance of the fact that an impulse turbine working with steam must work drowned, thus losing the advantage possessed in this regard by the type when actuated by water. The fact which faced turbine-builders in those early days was that the compound reaction turbine did not lend itself to a theoretical treatment, both simple and adequate, whilst the simple impulse type did. It was also thought at that time that the theory of velocity compounding was also very simple, and it was only sad experience that showed in this case the width of the gap between theory and practice. Guarantees were accordingly given light-heartedly by builders in all countries of the world, and it was the ensuing failure to realise anticipations that disillusioned engineers generally as to the possibilities of the system. Certain firms with special experience do, unquestionably, obtain excellent results with the type; but other firms, even with much experience with other patterns of turbine, have been much less successful when they have ventured to introduce velocity-compounded wheels. Of course, if the very highest efficiency be aimed at, the reaction machine probably stands unrivalled. Even the 20,000-kw. machine at Chicago has not exhausted the possibilities of the type, as the ratio of blade-speed to steam-speed is still well below the theoretical best value. Impulse machines, on the other hand, are nearing their limit, though in certain sizes it is, perhaps, possible to attain a reasonably high efficiency somewhat more cheaply with the impulse than with the reaction type, at least as usually constructed.

Water-Hammer.

In communications on water-hammer, presented last autumn to the Paris Académie des Sciences, the statement is made that the previous work on the subject has been mainly theoretical. That may be true as regards the researches of Allievi and Boussinesq, &c., to which particular reference is made, and as regards water-hammer in water-mains, but it does not apply to what engineers will be thinking of in the first instance—water-hammer in steam and boiler-feed pipes. Mr. Stromeyer has experimented a good deal on this water-hammer, and exhibited his apparatus during the Manchester meeting of the British Association last September. The two memoirs by C. Camichel, which appeared in the *Comptes Rendus* of September 20 and October 4, 1915, concern experiments with water-pipes and the mass oscillations set up by the more or less rapid opening or closing of a valve. Camichel first considers the case of pipes in which there are air-pockets of sufficient volume to render the dilatation of the pipe and the compressibility of the liquid negligible. The formula for a pipe having a single air-pocket at one extremity of the pipe was investigated by Rateau; Camichel confirms Rateau's formula and extends it to n pockets. In their experiments Camichel and Eydoux made use of two pipes, the one 12.5 metres long and 3.5 cm. in diameter, the other 30 metres long and 30 cm in diameter. Each pipe had at one end a tap which could be turned at different speeds by a motor. In the case of one air-pocket the period of mass oscillation was found proportional to the square root of the volume of the pocket; with several pockets several periods were observed, in agreement with the theory. The second paper deals with water-hammer in pipes free of air. The tap was opened very suddenly, and the diminution in pressure caused by this operation was recorded by a manometer; from the records of the direct and the reflected pressure wave (coming back from the tank), the speed of propagation of the wave was deduced. The experiments were made with an iron pipe, 154.5 metres in length, 80 mm. in diameter, and 5 mm. thickness. According to Joukovsky and Allievi, the speed of propagation of the wave should be $a = 9900/\sqrt{48.3 + k\,d/e}$, where k is a coefficient = 0.5, d the diameter, and e the wall thickness of the pipe. The calculated value of a was 1315 metres per second; the average of a series of observed values was 1280 metres. Thus the found value was too small; but the formula holds, as Boussinesq had pointed out, only for pipes with very thin walls, and the thickness in the experimental pipe of 150 metres length was not easy to estimate; the agreement is therefore satisfactory. Resonance waves were also studied, and the fundamental thrust, as well as its upper harmonics, observed. The experiments are to be continued, also with respect to the effect of the positions of air-pockets and to dangerous oscillation periods.

Water-Power Exploitation in Norway.—The first move has now been made towards the exploitation of the large Nore Falls, the property of the Norwegian State, inasmuch as the Storthing recently resolved upon the regulation of the Numedalslaagen, where the Nore Falls are located. The first work is the construction of the Tunhöod dam for regulation of the Tunhöod Fjord; it will be a concrete dam, in the first instance to be 10 metres high, but so constructed that the height afterwards can be raised to 18 metres, or, perhaps, even to 21 metres. Owing to conditions of the locality the height of crown is 37 metres and the length of the crown 280 metres. The blasting work for the foundation has already been done, and the dam is expected to be completed in the course of 1917. The place is 103 km. above Kongsberg.

Germany's Home Shipbuilding in War.—The *Broad Arrow*, which has greatly improved under the new *régime*, has an article by Mr. John Leyland on "What Are the Germans Preparing at Sea?" In the course of it he says:—There has been much speculation as to what the Germans have been doing at their shipyards during the war. That they have built submarines in considerable numbers we know, of which many have perished; while the activity of the rest is mostly in the Mediterranean. Some of them have reached Trieste by rail, and have been put together at the Stabilimento Tecnico there. The Germans must by this time have completed the battle-cruiser Hindenburg, which was launched on August 1, and two battleships, which were building severally at the Howaldt Yard, Kiel, and the yard of Schichau, at Dantzig, were due for completion in the spring of 1916. These three ships belonged to the programme of 1913, in which year they were laid down; and we know nothing of the ships of subsequent years, except that a battleship was put in hand at the Germania yard, Kiel, in 1914, in which year also a battle-cruiser was provided for. These must be already well advanced. But German shipbuilding resources are on an enormous scale, and we may be sure that they have not been idle. They have probably been employed, *inter alia*, in building commerce-destroyers of a special swift class, with good armament and some protection. What else they have been engaged on we do not know, though possibly the Admiralty may be informed.

INDUSTRIAL NOTES.

LORD READING, the Lord Chief Justice, has sent a communication to Mr. F. A. Gibson, Secretary of the South Wales Coalowners, and Mr. Thomas Richards, M.P., Secretary of the South Wales Miners' Federation, stating that he has appointed Lord Muir Mackenzie, G.C.B., to be the independent chairman of the South Wales Conciliation Board, in succession to Lord St. Aldwyn.

Committees are being formed in the following districts for ensuring that establishments engaged on munitions work and other large consumers of coal should obtain rapidly the supplies they require :—

1. Scotland.
2. Northumberland.
3. Durham.
4. Cumberland.
5. Lancashire, Cheshire, and North Wales.
6. West Yorkshire.
7. South Yorkshire.
8. Nottingham, Derby, and Leicester.
9. Staffordshire, Warwickshire, and Shropshire.
10. South Wales.
11. Somerset and Forest of Dean and Bristol Coalfield.

It will be the business of these committees to see that the resources of their districts are utilised to the best advantage, and that the requirements of important industries are fully met. Any recommendations that they may be able to make with a view to greater economy in the use of coal will be carefully considered.

It is not proposed to confer any special powers on these committees. It is felt that both coal-owners and consumers realise that the industries connected with the war must have precedence, and that some interference with the normal distribution of coal at the present time cannot altogether be avoided.

Mr. Runciman has appointed the following gentlemen to be a committee to consider all questions relating to the distribution of coal and coke that may be referred to them from time to time by the Board of Trade or submitted by the District Coal and Coke Supplies Committees :—

Mr. W. F. Marwood, C.B. (Board of Trade), Chairman.
Sir Richard A. S. Redmayne, K.C.B. (H.M. Chief Inspector of Mines), Vice-Chairman.
Mr. H. F. Carlill (Board of Trade).
Commander T. Fisher, R.N. (Admiralty).
Mr. J. C. Hamilton Greig.
Mr. F. J. Jones.
Mr. Leonard W. Llewelyn (Ministry of Munitions).
Mr. Arthur H. Pease.
Mr. K. W. Price (Ministry of Munitions).
Mr. F. Tatlow (Railway Executive Committee).
Mr. W. Walker (Deputy Chief Inspector of Mines).

Mr. W. A. Lee (Board of Trade) and Captain C. E. Williams (Ministry of Munitions) act as secretaries to the Committee.

An interesting discussion on "Puddling Problems and the Roe Puddling Process" is given in vol. xxx. of the Proceedings of the Staffordshire Iron and Steel Institute. In the course of his remarks on the question, Mr. D. Evans said that our experience and that of others had undeniably hitherto been that all attempts to manufacture tough, fibrous iron by way of mechanical puddling had been conspicuous failures. The well-known Danks process, from which forty years ago so great things were expected, was a striking illustration of this fact. . . . It was a singular reflection that after centuries of iron-making, it was still almost impossible to manufacture good puddled iron in units of more than 4 cwt. per heat per furnace on an average. . . . The cry about the difficulty of finding hand-puddlers was one which had been heard in the Staffordshire district for very many years, yet our forges continued to operate. He (the speaker) believed there would be a supply of intelligent able-bodied puddlers for many years to come, especially in works where any trouble in matters of detail had been met by a remodelling and rearrangement of the plant, by removing some of the old methods of getting iron from furnace to hammer and rolls, also by the introduction of mechanical aids of great utility, though of simple design. He did not imagine that there was any overpowering demand at the present time for some form or other of mechanical puddling in the rolled-iron trade of this country. Staffordshire iron was of such a fibrous quality that it commanded some of the highest prices in the world's markets. Therefore great caution had to be exercised before engaging in processes which might endanger that position, which Staffordshire had held for so many years.

The Durham Coal Trade Conciliation Board held a meeting last Friday, the 4th inst., at the Coal Trade Offices, Newcastle, with a view to regulate the miners' wages in the county for the ensuing three months. Sir Lindsay Wood, Bart., presided. At the November meeting the men received an advance of 11¼ per cent., including 5 per cent., the balance from the special advance granted earlier in the year, bringing wages up to 75 per cent. above the basis of 1879. At the Friday's meeting in question the miners' wages were advanced 3¾ per cent., to take effect as from last Monday, the 7th inst.

On Saturday last, the 5th inst., the committee of the Durham Deputies' Association met the owners at the Coal Trade Offices, Newcastle, when it was decided that the deputies' wages should also be advanced by 3¾ per cent. for the ensuing quarter, making wages 78¾ per cent. above the basis of 1879.

AN interesting episode in the relations of employers and labour leaders, says the American journal *The Iron Age*, takes the form of an agreement which, it appears, has been effected by the representatives of manufacturers and delegates of labour of the State of New York. Under this agreement, no Bills affecting wages and conditions of employment are to be introduced in the State Legislature without previously being submitted to a conference of representatives of both sides. This is believed to be the first time in the history of any State that such an understanding has been reached. Labour representatives themselves are of the opinion that less misunderstanding and strife will be the result. Up to this time, labour measures have been introduced in the Legislature through some friendly member, and employers have either been obliged to keep a representative at the capital, or have known nothing about such a Bill until it has reached a stage which almost ensured its passage. If hereafter Bills of this kind are only introduced after a conference of representatives of both sides, it is likely that labour legislation in the State of New York will be much less radical and more mindful of the interests of employers. The experiment is one which will be regarded with great interest outside as well as in the State.

The same American journal states that a comprehensive project for the mobilisation of the industries of the country engaged in the production of war material and the development and maintenance by private concerns of equipment designed for the manufacture of articles of the special types required for the United States army has been formulated by the Secretary of War. . . . Many private manufacturers stand ready to spend large sums for the special equipment of their plants to meet the requirements of the Government if they can be assured that orders would be placed with them should the War Department in any crisis require large supplies of ammunition, arms, &c., on short notice. The officials of the War Department are keenly appreciative of the attitude of these manufacturers, and have been much gratified at the assurances they have received, but heretofore they have not been in a position to accept any of the numerous offers, which, in the opinion of Government experts, would redound greatly to the advantage of the military establishment.

"BUILDING AND ORNAMENTAL STONES OF AUSTRALIA."—This is the title of a work prepared by Mr. R. T. Baker, the curator of the Sydney Technological Museum, and recently published by that institution with the authority of the Government of New South Wales. It refers more particularly to stones suitable for constructional, decorative, and monumental work and found in New South Wales, for the reason that these natural resources have been more fully developed in this State than in others, which may possess equally good stones. The marble found in New South Wales is remarkable for its strength and compactness of texture, the latter feature being of considerable commercial importance, since it facilitates thin cutting. It occurs in almost every variety of colour, from black to white, and, although the latter is not plentiful, as far as is known at present, such specimens as have been obtained are said to be quite equal in quality to Carrara. Australia is also particularly rich in granites, though not many have yet been worked. Red granites are found with fine and coarse grains, and many varieties of grey granite are also present. The finest of the latter is a dark-grey granite, found at Uralla, which is regarded as one of the best granites in the world. The book contains lists of the sources and properties of granite, gneiss, trachyte, porphyry, diorite, basalt, dolerite, marble, slate, serpentine, quartzite, and sandstone, and illustrates numerous fine buildings and other structures in which they have been employed; data of crushing tests and fire-resisting tests of many of the stones are also given. Perhaps the most noticeable feature of the publication, however, is the inclusion in it of a large number of three-colour, half-tone engravings, illustrating the appearance of the various ornamental stones; the beautiful figuring of the marbles and serpentines is extremely well shown in this way. The object of the work is to show that Australia has an unlimited supply of building and ornamental stones that lend themselves admirably to the purposes of decorative art, and that this object has been fully achieved will be evident from the most casual glance through its pages. A more careful study of its contents cannot fail to convince the reader that the stone-quarrying industry is destined to become a very important factor in the future prosperity of the Commonwealth, since its resources can supply not only its own requirements, but those of other parts of the Empire and foreign countries as well.

THE WORKING OF A RACK RAILWAY.*

By WILLIAM THEODORE LUCY, M. Inst. C.E.

THE paper recently presented to this Institution by Mr. Brodie H. Henderson, M. Inst. C.E., on "The Transandine Railway,"† dealt chiefly with the location and construction of the two railways forming the route between Argentina and Chile. These notes are intended to give further information as to the practical details of combined rack and adhesion working on the Chilian Transandine Railway, the more severe of the two lines, which the author had opportunities of observing and modifying. The work done on this rack railway is probably heavier than can be found elsewhere, and may be taken as double that described by Mr. J. Weber and Mr. S. Abt in a recent paper on "Swiss Mountain Railway Locomotives."‡

A brief description is given of the four different types of locomotives which were in use at the opening of the Chilian Transandine Railway in 1910, together with a short account of the history of the development of the more powerful engines. The conditions necessary in a combined adhesion and rack locomotive for an 8 per cent. (1 in 12½) gradient are considered in detail, comparisons being made between the Kitson-Meyer and the Esslingen types. The author contends that the plan hitherto generally accepted, of providing a separate frame, suspended on the carrying axles of the main frame, for carrying the rack pinions, is unnecessary, and he gives arguments in support of this. He also disagrees with the traditional method of driving the pinions by means of spring-keys, and advocates solid ones as having given better results. He advocates the flexibility in speed obtained by a direct drive on the pinions, and therefore is opposed to the introduction of gearing.

The eight separate brakes used on the Chilian Transandine Railway are dealt with, the value of the repression brake being particularly noted and modifications described which have added to its efficiency. The band brake, which is a usual feature on rack locomotives, is condemned, and reasons are given for its abolition.

Remarks follow on locomotive and train-working, including the method of entering the rack, the position of the engine on the train, coal consumption, train-lighting, &c.

A few notes are devoted to the permanent way and snow-clearing. The existing ploughs are mentioned, and a description is given of an appliance proposed by the author in the form of a bucket-ladder dredger for the removal of avalanches or hard snow mixed with rock.

Appendices give particulars of a locomotive proposed for the haulage of trains of 150 tons on the 8 per cent. (1 in 12½) gradient, and a list of the cab fittings used on the Chilian Transandine Railway serves to show the complicated nature of the work.

CONTRACTS.—The General Electric Company of China, Limited, Shanghai, report that they have for the sixth time secured the yearly contract for the supply of "Osram" traction-type lamps to the Shanghai Tramways.—The Monometer Manufacturing Company, Ltd., Aston, Birmingham, have received orders for complete batteries of their various furnaces for new arsenals.

THE JUNIOR INSTITUTION OF ENGINEERS.—In spite of the large proportion of its members either on active service or engaged on war work, the Junior Institution of Engineers has had a very successful session. Amongst the papers read at the general meetings held each month may be noted one on "Cast-Iron Foundry Practice," by Mr. Rawlinson, and another on "The Modernisation of Power Plant in Factories," by Mr. W. A. Tookey. The informal discussions held every Friday evening during the session have also been very successful. During the ensuing session Professor H. E. Armstrong, F.R.S., is to deliver a lecture on "Chemistry and Engineering." Two papers on electricity in factories will be read at dates to be subsequently announced.

SCIENCE AND TECHNOLOGY.—The report of the Board of Education on the examinations in science and technology held last year have now been published. As was to be expected, the war has adversely affected the candidates, of whom a larger proportion than in 1914 proved to be unprepared, and the complaint is made that the schools entering candidates have not exercised due care in this regard. It is, of course, merely a waste of time to permit "hopeless" candidates to sit at the examinations. Apparently great importance is being attached to laboratory work, and managers and teachers are warned that, unless proper facilities are provided, the students should not be allowed to sit. In fact, the department appear to be perhaps less concerned with the extent and accuracy of the student's knowledge than with the conditions in which he gained it. We note that poor results are recorded in the subject of practical mathematics. This is, no doubt, partly due to the prevalence of the idea that this study provides a Royal road to mathematical knowledge, and the necessary drill in the handling of algebraic expressions is accordingly insufficiently enforced. Practical mathematics in its elementary stages serve as an excellent introduction to pure mathematics, but an adequate knowledge of the latter is absolutely necessary to a mastery of the higher branches of practical mathematics.

* Abstract of a paper read before the Institution of Civil Engineers, Tuesday, February 8.

† Minutes of the Proceedings of the Institution of Civil Engineers, vol. cxcv., page 151.

‡ Proceedings of the Institution of Mechanical Engineers, 1911, vol. iii.

TURBO BLOWERS AND COMPRESSORS.*

By H. L. GUY and Lieut. P. L. JONES, B.Sc.

DEFINITION OF SYMBOLS.

C = Absolute velocity of air in feet per second.
D_1 = Diameter of impeller in inches.
D_2 = Diameter of diffuser in inches.
d_m = Mean density of air in pounds per cubic foot.
F = Area at throat of nozzle in square feet.
g = 32.2 ft.-sec. per second.
J = Joule's equivalent = 778 ft.-lb. per B.T.U.
M = Weight of air compressed in pounds per second.
M_c = Weight of circulating water in pounds per second.
n = Indicates speed in revolutions per minute.
P_B = Barometric pressure.
p_0 = Gauge pressure at blower or compressor suction.
P_0 = Absolute pressure at blower or compressor suction = $P_B - p_0$.

Fig. 1.

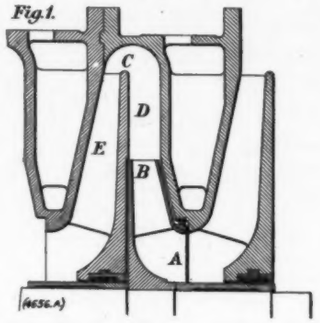
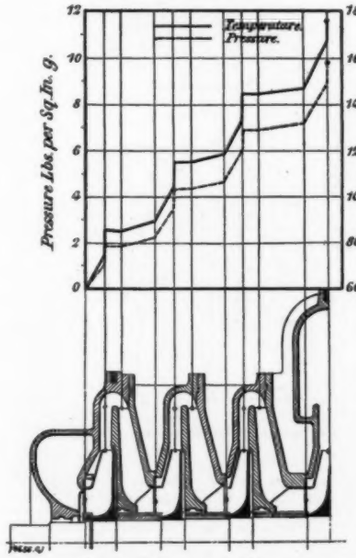


Fig. 3. VARIATION IN TEMPERATURE & PRESSURE IN A 4 STAGE BLOWER.



p_f = Gauge pressure at blower or compressor discharge.
P_f = Absolute pressure at blower or compressor discharge = $p_f + P_B$.
p_n = Gauge pressure measured by a Pitot tube before measuring nozzle on discharge side.
P_n = Absolute pressure measured by a Pitot tube after measuring nozzle on discharge side = $p_n + P_B$.
p' = Gauge pressure measured by a static tube after measuring nozzle on suction side.
P' = Absolute pressure measured by a static tube after measuring nozzle on suction side = $P_B + p'$.
Q = Volume of free air in cubic feet per minute.
R = Constant in relation P V = R T, and R = 53.3 for air.
t_0 = Initial temperature in deg. Fahr.
T_0 = Absolute initial temperature = 461 + t_0.
t_f = Final temperature at discharge in deg. Fahr.
T_f = Absolute final temperature = 461 + t_f.
t_n = Temperature before measuring nozzle in deg. Fahr.
T_n = Absolute temperature before measuring nozzle = 461 + t_n.
V = Specific volume of air in cubic feet per pound.

W = Work in brake horse-power.
W_{ad} = Work done in adiabatic compression in brake horse-power.
W_{is} = Work done in isothermal compression in brake horse-power.
a = Used to indicate an angle.
η_{ad} = Efficiency relatively to adiabatic compression.
η_{is} = Efficiency relatively to isothermal compression.
η_{in} = Internal efficiency, neglecting bearing losses.
λ = Ratio of specific heat at constant pressure to that at constant volume = 1.41 for air.

When "free air" is referred to, air measured at 30 in. Hg barometer and 60 deg. Fahr. is to be understood.

Perhaps the most marked feature in the recent history of power production has been the replacing of reciprocating machinery by that of the rotary type. The steam-turbine has invaded and captured a considerable portion of the fields of usefulness of the reciprocating steam-engine. The centrifugal water-pump has largely replaced

Fig. 2. RISE OF TEMPERATURE DURING ADIABATIC COMPRESSION.

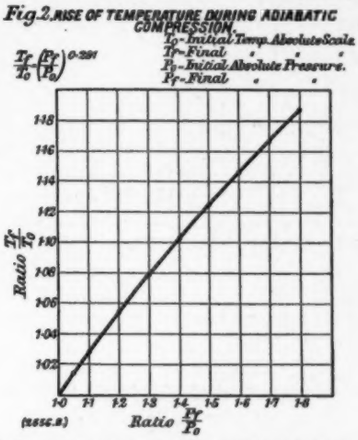


Fig. 4. CONSTANT SPEED CHARACTERISTICS OF A BLOWER.

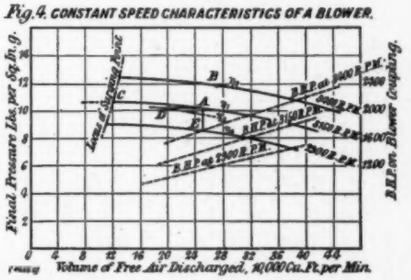
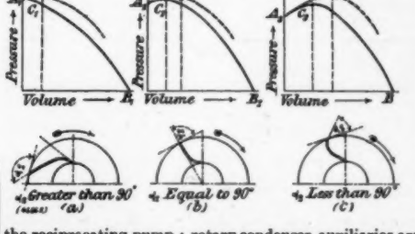

Final Pressure Lbs. per Sq. In. g.
Locus of Surging Points
B.H.P. on Blower Coupling.
Volume of Free Air Discharged, 1000 Cu. Ft. per Min.

Fig. 5. EFFECT OF BLADE SHAPE ON SURGING POINT.



the reciprocating pump; rotary condenser auxiliaries are rapidly superseding reciprocating plant, and rotary air-blowers and compressors have entered into a successful contest with reciprocating compressors. The factors which have decided the issue in favour of rotary plant hold for all the types mentioned. They are stated generally:—

1. *Small space occupied* and light weight—a fact resulting from high speed.
2. *Excellent balance*, due to the elimination of reciprocating elements.
3. *Light foundations*, which result from 1 and 2.
4. *Low first cost*, resulting from 1 and 3.
5. *Simplicity*. No valves and valve-gear other than the governor.
6. *Maintenance of efficiency* owing to absence of valves and rubbing parts. The wear of valves is responsible for much of the heavy drop in efficiency in reciprocating plant.
7. *Reliability*, resulting from its extreme simplicity.
8. *Accessibility*. All internal parts can be examined by raising top casing.
9. *Efficient Lubrication*. The rotary bearings of the machine are fed by a self-contained lubricating system which uses the same oil continuously, the renewal of oil being only necessary after long periods, so that the oil charge is very small.
10. Low maintenance costs, resulting from 5, 6, 7, 8 and 9.

Machinery which can be driven by a steam-turbine has the additional and valuable advantage that a mixed-pressure turbine can be employed utilising waste steam, a large quantity of which is usually available. The turbo-blower is really a multi-stage centrifugal air-pump. Air is drawn into the eye of the first impeller *A*, Fig. 1, and delivered at the periphery *B* in a compressed condition. It can be shown that if the compression is performed without loss, the equivalent of half the work done is transformed into pressure energy of the air $\left(M \frac{P_f - P_0}{d_m}\right)$, the remaining half being present as kinetic energy $\left(\frac{MC_1^2}{2g}\right)$.

On leaving the impeller the air now enters the diffuser *D*, the object of which is to convert the kinetic energy into potential energy. $\left\{\text{Rise of pressure} = \frac{C_1^2}{2g} d_m \left(1 - \frac{D_1^2}{D_2^2}\right)\right\}$ so that in a perfect blower at the point *C* outside the diffuser, the pressure energy in the air would be equal to the work done in the impeller. The air now passes through the guide-blades *E*, which direct it into the eye of the second impeller, where the process is repeated. Although the operation is very similar to that in a centrifugal water-pump, there are important differences in the working of the two classes of machines.

1. For a given peripheral speed, the terminal pressure is proportional to the density of the medium; hence the pressure produced in the impeller of the blower is about $\frac{1}{815}$th of the pressure which would be produced with water, water being 800 times as heavy as air. For this reason it is always necessary to build blowers, even for such low terminal pressures as 5 lb. per sq. in., with more than one impeller, and for the more usual pressures of from 8 lb. to 15 lb. per sq. in. it is necessary to employ three, four, or even five stages.

2. In a water-pump the density remains constant, and therefore the increase in pressure per stage is constant; but in a blower the pressure and temperature of the air changes, resulting in a change of density, so that the increase in pressure per stage is continually increasing. The rise in temperature is due to two causes:—

(*a*) The rise associated with adiabatic compression, which is given by the expression:—

$$\frac{T_f}{T_0} = \left(\frac{P_f}{P_0}\right)^{\frac{\lambda - 1}{\lambda}} = \left(\frac{P_f}{P_0}\right)^{0.291}$$

This relation has been plotted in Fig. 2.

(*b*) The rise due to the fact that the compression is accompanied by loss in friction, leakage, and eddies. The internal efficiency of a blower relatively to adiabatic compression is given by $\eta_{in} = \frac{T_n - T_0}{T_f - T_0}$, so that the actual temperature rise in a blower is equal to that corresponding to adiabatic compression divided by the internal efficiency.

Assuming the blower is to compress air from atmospheric pressure and 60 deg. Fahr. to 10 lb. per sq. in. gauge, then the rise of temperature due to adiabatic compression is 84.8 deg. Fahr. If the internal efficiency is 75 per cent., the actual rise in temperature will be $\frac{84.8}{0.75} = 113$ deg. Fahr., so that the temperature of the air at delivery will be 113 + 60 = 173 deg. Fahr.

Fig. 3 illustrates the changes in pressure, temperature, and specific volume of the air in a typical four-stage double-flow blower. If the speed of rotation is kept constant, the volume of free air delivered by the blower is connected with the terminal pressure by a falling curve of the type illustrated in Fig. 4 (curve C A), which was obtained from one of the four blowers supplied by the British Westinghouse Company to the Partington Iron and Steel Company, which were specified to deliver 25,000 cub. ft. of free air per minute at a pressure of from 10 lb. to 12 lb. per sq. in. gauge. On the same diagram is shown similar characteristics of other speeds. These can be obtained as follows:—

If the speed of the blower is increased from n_1 to n_2, then to each point *A* on the characteristic n_1 there is a corresponding point *B* on characteristic n_2, such that $Q_2 = Q_1 \times \frac{n_2}{n_1}$, and $p_2 = p_1 \times \left(\frac{n_2}{n_1}\right)^2$, and it can be shown that the efficiencies at *A* and *B* are sensibly the same. Thus it follows that if W_1 is the power taken by the blower for condition *A*, and W_2 the corresponding power for condition *B*, then $W_2 = W_1 \times \left(\frac{n_2}{n_1}\right)^3$—*i.e.*, the quantity varies directly as the speed, the pressure varies as the square of the speed, and the required driving power varies as the cube of the speed. As the volume of the air delivered is decreased, the speed being kept constant, the pressure rises until the maximum is reached at *C*. *C* is called the "surging point." Without some external adjustment it is impossible for the blower to deliver a smaller volume of air than Q_c at this speed, for the reason that at this point violent oscillations are set up, and the conditions in the blower are quite unstable. The surging point is analogous to the point at which a centrifugal pump having a similar characteristic "loses its water." It has been found that the surging point of a blower having leaning-back blades occurs when the volume delivered is approximately 40 per cent. of that for which the blower is designed. As has already been mentioned, the surging point coincides with that part of the constant-speed characteristic where the pressure reaches a maximum. It is therefore of interest to notice how this is modified by the shape of the impeller-blades.

With "leaning-back blades," such as shown at *a* (Fig. 5), where the blade forms an angle greater than 90 deg. at the outer diameter in the direction of rotation, the

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characteristic follows the curve $A_1C_1B_1$, in which the pressure is a maximum at A_1. The addition of a diffuser, which is necessary if high efficiencies are to be obtained, modifies the characteristic to the dotted curve A_1D_1, the surging point of the combination being at D_1.

With "radial blades" (*b*), in which the leaving edge is radial, the characteristic for the impeller is $A_2C_2B_2$, the surging point of the impeller being at C_2 and of the impeller and diffuser at D_2, both of which points correspond to a greater volume than when leaning-back blades are used.

With "leaning-forward blades" (*c*), where the blade at the outer diameter forms an angle less than 90 deg. in the direction of rotation, the characteristics for the impeller with a diffuser are the curves $A_3C_3D_3$ and $A_3D_3B_3$ respectively, in both of which the surging points C_3, D_3 correspond to greater volumes than with radial blades. It is therefore important to use leaning-back blades in blower impellers.

In order to ensure that the blower shall never operate at the unstable portion of its characteristic, a surging valve is provided which is opened either by hand or automatically when the volume of air discharged reaches some value a little greater than that corresponding to the surging point. Such a valve is shown at *S* in Fig. 6, and is operated either by a multiplicator, the action of which will be described later, or by arranging the bottom of the spindle of the non-return valve of such a length that in closing it commences to push the surging valve open when the non-return valve is a certain distance off its seat.

Design.—The design of the turbo-blower follows the same general lines as that of a centrifugal water-pump. The speed of rotation determines the dimensions of the machine. Blowers are most commonly driven by steam-turbines, and the combination is extremely favourable, since while the high speed of rotation which is possible results in a small, and therefore cheap, blower, it also results in an inexpensive and efficient turbine. The speed of rotation is limited by the maximum permissible speed of the turbine or other driving machine. Having fixed the revolutions per minute, the diameter of the impeller is determined by the fact that the peripheral speed is limited by the centrifugal stresses induced. Impellers have been run up to a peripheral speed of 720 ft. per second, but the limit will be fixed by the physical properties of the materials used in the construction of the impeller, the character of its design, and by the factor of safety chosen by the designer. This factor of safety is usually of the order of 5 to 6 on the ultimate strength, which is very ample, having regard to the steady nature of the stresses and the gradual manner in which they bearings is increased beyond a certain amount, it may happen that the first critical speed is so low that danger might be expected from the second critical speed. In such a case the impellers should be arranged in two casings. The brake horse-power required on the blower coupling can be obtained from Fig. 16, which is plotted from the relation: Adiabatic work for compressing 10,000 three-way cock. If the resistance of the furnace decreases, the pressure at the blower discharge tends to fall, reducing the pressure under piston *A*, which is therefore forced down by the spring. As the speed-governor only comes into operation at the highest speed for which the blower is constructed, points *D* and initially *E* are fixed, and therefore the pilot-valve *C* is lowered, thus admitting oil-

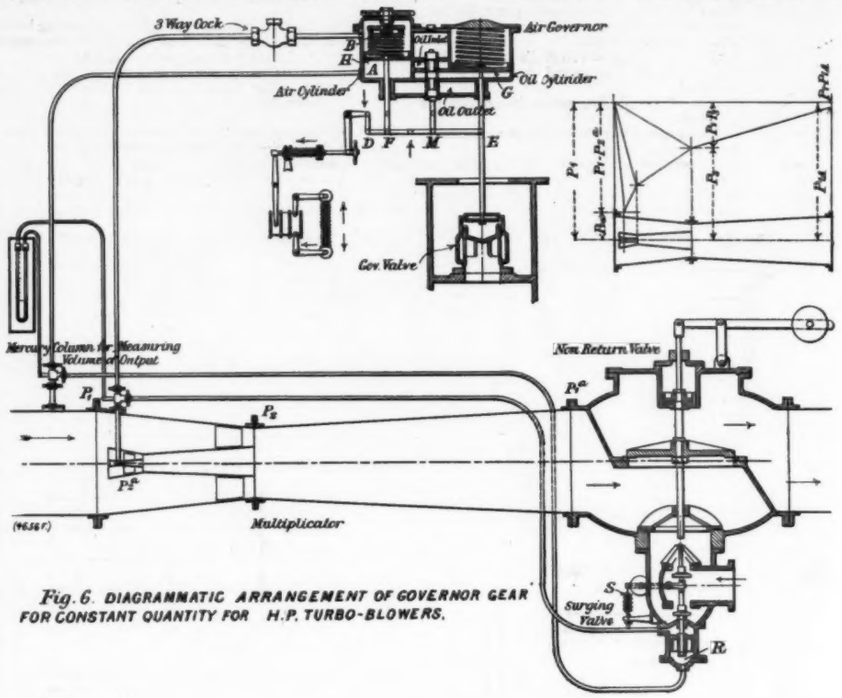


Fig. 6. DIAGRAMMATIC ARRANGEMENT OF GOVERNOR GEAR FOR CONSTANT QUANTITY FOR H.P. TURBO-BLOWERS.

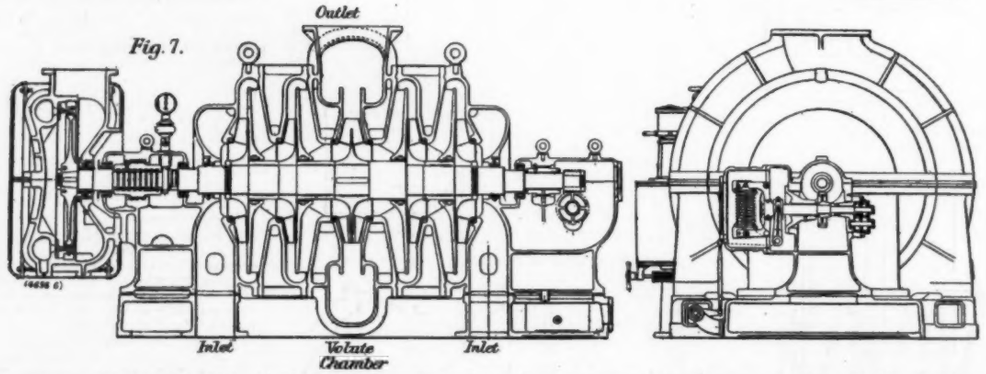


Fig. 7.

arise. The increase in pressure which will be obtained per stage can be approximately determined by the following formula:—

$$\Delta p = \frac{1}{480} \cdot \frac{D_1^2}{v} \cdot \left(\frac{\text{R.P.M.}}{1000}\right)^2,$$

where

D_1 = the diameter of impeller in inches;
v = the mean specific volume in cubic feet per pound;
Δp = the pounds per square inch rise in pressure, one stage.

There is always an unbalanced force on impellers tending to urge them towards the suction side. This is balanced in many ways, the most common methods being:—

1. Arranging the blower as a double-flow machine.
2. Balancing each impeller separately.
3. Balance pistons.
4. The use of thrust-blocks, which may be of the Michell type.

Turbo-blowers are generally arranged on the double-flow principle, since this gives reasonable dimensions for usual capacities. In this design the air is drawn in at both ends of the casing and discharged in the centre; there is in consequence very little unbalanced axial force.

A blower arranged in this manner is shown in Fig. 7, which is a section through a set supplied to Messrs. Gjers Mill, which delivers 30,000 cub. ft. of free air per minute at a pressure of 6½ lb. to 8 lb. per sq. in. gauge, and is driven by a back-pressure turbine. The steam for this turbine is supplied by boilers fired with blast-furnace gas, and the steam at exhaust is sold to a waste-heat company. In blower practice it is usual for the running speed to be about 30 to 40 per cent. above the first critical speed of the rotor. If the length of the shaft between cub. ft. of air per minute drawn in at temperature t deg. Fahr. is given by

$$W_{a\,d} = 2115 \left\{ \left(\frac{p_f}{p_0}\right)^{0\cdot 291} - 1 \right\} \frac{t_0 + 461}{493} \text{ B.H.P.}$$

For Example.—A blower required to deliver 35,000 cub. ft. of free air at a pressure of 10 lb. per sq. in., the temperature at suction being 60 deg. Fahr.

$$W_{a\,d} = 3.5 \times 2115 \left\{ \left(\frac{24.7}{14.7}\right)^{0\cdot 291} - 1 \right\} \times \frac{521}{493} = 1273 \text{ H.P.}$$

Assuming an over-all efficiency of 72 per cent., the power required at blower coupling is equal to

$$\frac{1273}{0.72} = 1770 \text{ B.H.P.}$$

GOVERNING.

1. *Constant Pressure.*—A blower can be arranged in such a manner that the pressure at discharge remains sensibly constant. In ordinary practice, in which the quantity may vary from 80 to 120 per cent. of its normal output, the pressure at delivery may be maintained constant within limits of $\pm \frac{1}{4}$ lb.

Referring to blower characteristics, Fig. 4, in which point *D* refers to the pressure when the blower is delivering 20,000 cub. ft. per minute, it will be seen that as the volume delivered is increased to 25,000 cub. ft. per minute, the pressure follows the path *D A*, the speed of the blower rising from n_2 to n_1. With this type of governing the volume discharged by the blower will depend on the internal resistance of the furnace, and since this is not constant, the quantity delivered is continually varying. In the constant-pressure governor-gear illustrated in Fig. 6, which is of the oil-relay type, the spring-loaded piston *A* is connected on its underside to the discharge of the blower, and on the top side to atmosphere through the pressure to the underside of piston *C*. The governor-valve is then raised, and the speed of the turbine rises sufficiently to maintain the pressure at about its original value; at the same time the pilot-valve is returned to its mean position and the governor-gear is again in equilibrium. The hand-wheel K is provided to allow the gear being set for any pressure within 20 per cent. of the normal.

2. *Constant Volume.*—If it is desired to supply the furnace with a sensibly constant quantity of air which shall be independent of small variations in furnace resistance, a governor of the type just described can be employed if slightly modified and used in conjunction with a multiplicator. If a fluid flows through a Venturi pipe, such as is shown in Fig. 6, the difference in pressure immediately before the pipe and at its minimum diameter ($P_1 - P_2$) increases with the quantity flowing through it. If ($P_1 - P_2$) is not sufficient to operate a sensitive piston, this difference can be multiplied by placing a second Venturi meter in the first, as indicated in Fig. 6, and so on. In this way a pressure difference of several pounds per square inch is obtained. A multiplicator can be calibrated so as to indicate the volume of air discharged by the blower; but it is usually found that drivers gauge the output of a turbo-blower by the pressure after the governor-valves, this being roughly proportional to the work performed by the turbine. The multiplicator can also be utilised to operate the surging valve by connecting the two as shown in Fig. 6. The surging valve will initially be open, but when the volume has increased to such an extent that the drop in pressure across the piston *R* is sufficient to overcome the tension of the spring, the valve will close.

When it is desired to govern for constant volume, the underside of piston *A* is connected to the discharge main immediately before the multiplicator, while the upper

side *B* is connected by turning the three-way cock to the throat of the innermost Venturi tube of the multiplicator; hence the pressure across the piston increases with the quantity discharged. If the furnace resistance decreases, the quantity discharged tends to increase, thus increasing the pressure above the sensitive piston, which, rising, lifts the pilot-valve, releasing the oil pressure under power piston *G*, and so allows the governor-valve to close sufficiently to maintain the volume of air discharged at about its original volume. This system of governing is illustrated in Fig. 4, in which *A* represents the first condition and *E* the second, the speed falling from n_1 to n_2, and the pressure from 10.2 lb. to 8.5 lb. per sq. in. gauge. By this means it can be arranged to maintain the volume constant between $\pm$ 5 per cent. of the normal quantity within the desired pressure limits. By operating the blower, and the remarks which have been made on blowers apply in general to the turbo-compressor. Turbo-compressors are made with capacities varying from 3000 cub. ft. to 50,000 cub. ft. per minute, a popular unit being 7500 cub. ft. per minute. As compared with a blower, the smaller air output results in compressors being made usually of the single-flow type, and the high pressures, with a correspondingly increased temperature rise in the air, necessitate some provision being made to cool the air during compression, so that an efficient machine may be obtained. Suppose, for example, that 7500 cub. ft. of free air is compressed to 80 lb. per sq. in. in a blower having an adiabatic efficiency of 72 per cent., the final temperature would be 580 deg. Fahr., the power taken to drive the blower being 1675 brake horse-power. If the compression is performed at constant temperature (isothermal compression), by cooling the air during compression, the B.H.P. required on the compressor coupling can be obtained from Fig. 18, which is plotted from the relation :—

Isothermal work for compressing 10,000 cub. ft. of free air per minute, drawn in at a temperature of t deg. F.

$$W_0 = 611 \left(\frac{461 + t^\circ}{493}\right) \log_e \left(\frac{P_r}{P_0}\right) = 1205 \text{ B.H.P.}$$

advantage be kept separate. After passing through the blower the air is discharged at *D*, passing through the non-return valve *NRV* into the distributing main *E*. The surging valve is shown at *SV* immediately above the non-return valve, and is operated either by the non-return valve-spindle or by a hand-wheel in the engine-room. The discharge from the surging valve *E* is preferably taken to a silencer *S*. In this particular installation the blower is driven by a mixed-pressure steam-turbine, which is supplied with a Le Blanc multi-jet condenser, the pumps being engine-driven.

TURBO-COMPRESSORS.

The turbo-compressor is a rotary air-pump which delivers air at a pressure usually between 50 lb. and 100 lb. per sq. in. In principle it is identical with the turbo-

Fig. 8. TYPICAL TURBO-BLOWER INSTALLATION

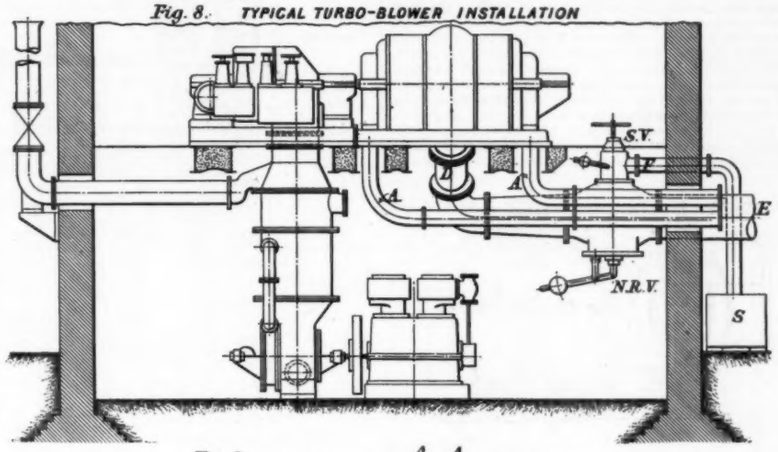


Fig. 9.

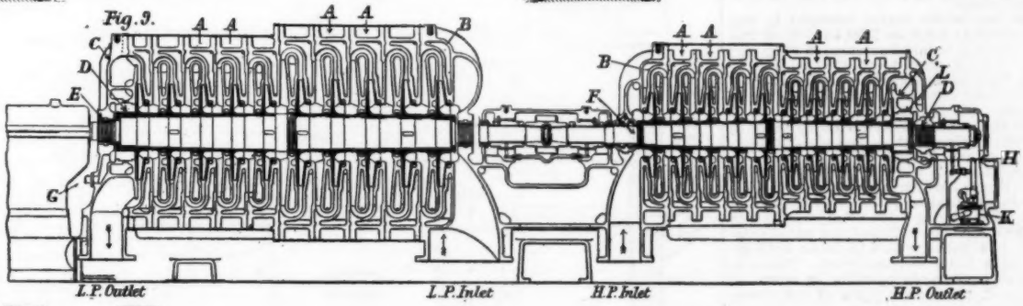


Fig. 10.

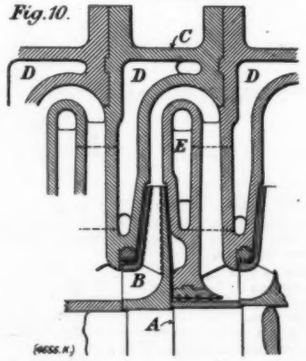
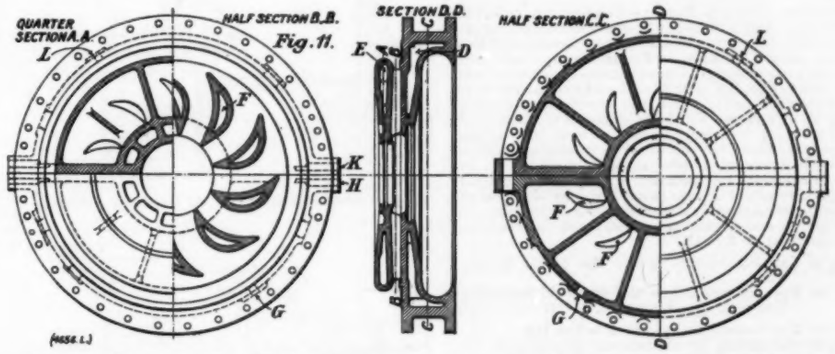


Fig. 11.



The second factor is separately plotted on the curve as the inlet temperature correction. The brake horse-power for isothermal compression of 7500 cub. ft. of free air per minute to a pressure of 80 lb. per sq. in. is therefore 903 brake horse-power, which is only 53.8 per cent. of the work which would be done if the compression took place adiabatically.

In the above example, the work done in isothermal compression of 7500 cub. ft. equals 903 brake horse-power, and the heat equivalent of this work (2,300,000 B.Th.U. per hour) must be transmitted through the cooling surface as it is generated. The efficiency of a compressor is stated as the ratio of the work actually done to that necessary with isothermal compression, and on this basis an efficiency of from 60 to 66 per cent. can be obtained. Assuming an efficiency of 60 per cent. relatively to isothermal compression, the work done would be 1506 brake horse-power, so that, if the temperature of the air at discharge is 190 deg. Fahr., sufficient cooling surface must be provided to carry off 2,769,000 B.T.U. per hour.

Fig. 9 shows a section of a compressor supplied by the British Westinghouse Company and installed at Welbeck Pit, rated at 7500 cub. ft. of free air per minute at 80 lb. per sq. in. The compressor consists of twenty stages, of which ten form the low-pressure cylinder and ten the high-pressure cylinder. The two sets of impellers are mounted so that the unbalanced thrust of the one opposes that of the other, the residual thrust being taken up by the balance-piston L. (Sections through a single stage are shown in Figs. 10 and 11.) The cooling-water enters at *G*, passes into chamber *D*, then through the hollow guide-vanes *F* to the chamber *E*; it returns through the neighbouring hollow guide-vanes to the chamber *D*. This path is repeated until the outlet *L* is reached, the water having passed backwards and forwards three times. The whole of the surface other than the impeller is water-jacketed, and as the air brushes across the surface at a high speed, the rate of heat transmission is very high. When sufficient surface cannot be provided inside the compressor, external coolers of the surface-condenser type are resorted to. For maximum efficiency a definite relation exists between the radial and peripheral velocities of the air at the outlet from the impeller, necessitating a reduction in its diameter in the successive stages of a compressor.

Speed-Governing.—While the two systems of governing just outlined present several attractive features, it is usually found that all normal requirements can be met by the ordinary type of constant speed-governing, such as is used on a turbine driving a generator. The apparatus then becomes much simpler, and consequently less costly, and more readily understood by drivers. In such a case the characteristic of the blower should be a flat one, such as that shown in Fig. 4, in which a reduction in output from 30,000 cub. ft. per minute to 20,000 cub. ft. per minute results in a pressure rise from 9.8 lb. to 10.4 lb. per sq. in. A hand adjustment in speed is provided, which allows a variation of at least 5 per cent. up or down, corresponding to a change in pressure of 20 per cent. at constant volume, or over the full effective volume range at the mean pressure.

Typical Lay-Out of Turbo-Blower.—Fig. 8 shows a typical lay-out of a turbo-blower based on the installation which was supplied to the Biddulph Valley Iron Works of Messrs. R. Heath and Co. The blower is of the double-flow type, rated at 30,000 cub. ft. per minute at a pressure of 8 lb. to 12 lb. per sq. in. The air is drawn from outside the station through the air-ducts *A*, *A*, which may with hand-wheel *K* the volume for which the gear is set can be altered within limits 20 per cent.

Surging Point.—The surging point in a compressor having curved leaning-back blades in the impellers is reached when the output is reduced to 30 per cent. of that for which it is designed. Compressors, as a rule are required to work over a greater range of volume than blowers, so that particular care has to be taken in the shape of the impeller blade, the design of which materially affects the minimum volume of air which the compressor can discharge. For this reason the blades of a turbo-compressor impeller should be sloped back at a considerable angle, necessitating the use of a curved blade. The construction, though more expensive than the adoption of straight blades, is justified by the lowering of the minimum possible output. By operating on butterfly valves placed in the air-ducts on the suction side of the compressor cylinders, the surging point can be reduced to 20 per cent. of the designed output; this device is an invention of Professor Rateau. A surging valve is provided which opens when the output is reduced to the minimum just referred to, and through it sufficient air is passed to keep the total discharged by the compressor above the critical value.

Such a valve is shown in Fig. 12, where *B* is the surging valve and *A* a non-return valve placed in the discharge-main. The height of the non-return valve from its seat

depends upon the amount of air passing through it. At full discharge A is at the top of its lift, the end of the spindle is above the lever E, to which it is not attached, and the surging valve B is closed by the spring C. The non-return valve-spindle is of such a length that it comes into contact with E when the discharge has decreased to a value a little above the surging point; any further decrease in output will cause A to fall and the surging valve to open.

GOVERNING.

1. *Constant Pressure.*—A compressor can be arranged with constant pressure-governing, in which case a maximum pressure variation of ± 3 per cent. is a reasonable one to specify. The governing in the case of British Westinghouse compressors is effected by means of an oil relay of the type shown in Fig. 13. The underside of the spring-loaded piston A is connected to the discharge of the compressor, so that with a fall in pressure A moves the pilot-piston H down from its mid-position, thus connecting port N with M, a supply of oil under pressure. The power-piston J is then lifted, raising the turbine governor-valve, which is attached to the spindle G; this motion returns the pilot-valve to its mid-position. The turbine then speeds up, increasing the air pressure, and a condition of equilibrium is reached with the pressure sensibly at its normal value and the turbine running at an increased speed. When the speed of the turbine rises above a predetermined value, a centrifugal governor comes into action, the constant pressure gear having reached the limit of its range. The air pressure for which the gear is set can be varied ± 10 per cent. by means of the hand-wheel D.

2. *Constant Speed.*—As in the case of blowers, constant speed-governing can be adopted with the advantage that the machine is simpler and the governing more direct. In such a case the governor would control the speed within 2 per cent. from normal air discharge down to the surging point, so that the pressure would vary 4 per cent. more than is given by the constant-speed characteristic. This variation in pressure is corrected by a hand adjustment of speed on the governor.

Typical Lay-Out of Turbo-Compressor.—Fig. 14 shows a typical lay-out of a turbo-compressor based on an installation which was supplied by the British Westinghouse Company to Messrs. Angus Scott and Partners for Brodsworth Main Colliery.

The compressor has twenty stages, arranged in two cylinders, and is normally rated at 7500 cub. ft. of free air per minute against a terminal pressure of 80 lb. per sq. in. gauge, the normal speed being 4100 revolutions per minute. Air is drawn in through the inlet-duct A, passing through the butterfly valve B_1 to I_1, the inlet of the low-pressure cylinder. After passing through ten stages it is discharged at D_1, passing through butterfly valve B_2 into the high-pressure cylinder at I_2, and then through ten high-pressure stages to the final discharge D_2. The air then flows through a non-return valve NRV and sluice-valve SV into the distributing main. Butterfly valves B_1 and B_2 are operated at light loads to reduce the surging point. The surging valve SV discharges into the silencer S. The compressor is driven by a mixed-pressure turbine which is supplied with a Le Blanc multi-jet condenser, the pumps being engine-driven. Water is supplied to the compressor-cooling jackets by means of a centrifugal pump P, passing via pipes E and return pipe F.

Commercial Testing of Blowers.—The principal object in view when testing a blower is to enable the actual output and over-all efficiency to be calculated. During the test readings should be taken at five-minute intervals, and after these have reached a steady state, a continuous test of one hour's duration is quite sufficient and satisfactory. The conditions under which the blower is operating during an official test should be adjusted to correspond closely to those for which guarantees have been given, because corrections for variations in conditions must be kept small if reasonable accuracy is to be obtained. In order to calculate the quantity of free air discharged through a standard nozzle per minute by the method outlined in the Appendix it is only necessary to make the following measurements, the position of the readings being indicated in Fig. 15.

t_a = The temperature before the nozzle in deg. Fahr.

p_a = The pressure before the nozzle in inches Hg measured by a Pitot tube.

P_a = The barometric pressure in inches Hg.

For the calculation of the internal efficiency of the blower relative to adiabatic compression, it is necessary to make the following additional measurements:—

t_0 = The temperature at the blower inlet in deg. Fahr.
(In the case of double-flow blowers, the average temperature at both inlets.)

t_f = The temperature after the blower in deg. Fahr.

p_f = The pressure after the blower in inches Hg, as measured by a Pitot tube.

The internal efficiency is then

$$\eta_{in} = \frac{t_a - t_0}{t_f - t_0}.$$

The speed of the blower in revolutions per minute should also be noted.

Corrections for Volume of Free Air Delivered.—Since the work done during compression is proportional to the volume of free air delivered, a change in the latter will result in a directly proportional change in the steam consumption. This is only true for changes of such a magnitude that the efficiencies of the turbine and blower remain sensibly constant.

If

Q_s = specified quantity of free air in cubic feet per minute, and

Q_a = actual quantity delivered on test,

the correction of steam consumption for air quantity is equal to:—

$$\left(\frac{Q_s}{Q_a} - 1\right) \times 100 \text{ per cent.}$$

Final Pressure and Barometer Pressure Correction for Driving Power.—The performance of a blower is usually specified with 30-in. barometer pressure at inlet. The horse-power taken to drive a blower discharging a definite volume of free air per minute will be the same if the ratio of compression $\frac{P_f}{P_0}$ and the efficiency is the same. On test the air may be measured by a nozzle on the blower discharge side, in which case P^1 is equal to P_a, the barometric pressure; hence the work done will vary with the barometric pressure unless the final pressure is changed from that specified sufficiently to keep the pressure ratio constant. For example, if a blower is specified to compress air from 30 in. barometer to 10 lb. per sq. in. gauge, and at the time of the test the barometer is 29 in., then the test should be made with a final pressure of 9.67 lb. per sq. in. if corrections are to be kept small. If the air dealt with by the blower is measured by a nozzle on the suction side, or if the suction air-ducts are long and of insufficient area, the correct pressure ratio will be $\left(\frac{P_f}{P_a - p'}\right)$, where p' is the pressure measured by a static tube on the blower side of the nozzles or air-duct.

Inlet Temperature Correction of Driving Power.—A blower is usually rated with an air temperature of 60 deg. Fahr. at inlet, and any change in inlet temperature necessitates a correction being made for the horse-power required to compress a definite volume of free air. The work done in adiabatic compression is proportional to the absolute initial temperature of the air, and the same holds for isothermal compression. Thus, if t_a deg. Fahr. is the inlet temperature during a test, and t_s deg. Fahr. is that specified, the corresponding corrections will be equal to:—

$$\left\{\left(\frac{t_a + 461}{t_s + 461}\right) - 1\right\} \times 100 \text{ per cent.}$$

This correction is plotted as a coefficient in Fig. 16.

Barometric Pressure. Correction of Free-Air Volume.—The air volume flowing through the blower reduced to 60 deg. Fahr. and a 30 in. barometer varies directly as the barometric pressure.

The following figures, which will serve as an illustration of the remarks which have just been made, were obtained on the official test of one of two turbo-blowers supplied by the British Westinghouse Company to Messrs. W. Baird and Co., for their Gartsherrie Iron Works. The blowers were specified to deliver 26,000 cub. ft. per minute at a pressure of either 4½ lb. or 6 lb. per sq. in., and are now regularly working at an output of 30,000 cub. ft. per minute.

Duration of test	60 min.
Barometer at 32 deg. Fahr. ...	29.6 in. Hg.
Temperature of free air in engine-room	67.245 deg. F.
Speed shown on tachometer ...	2587 R.P.M.
Pressure at blower suction, W.G., 2.33 in.	0.172 in. Hg.
Temperature at blower suction (t_0 = 67.24 deg. F.)	T_0 = 528.24 F.
Final temperature	t_f = 132.4 deg. F.
Final pressure (4.75 lb. per sq. in. g.)	9.68 in. Hg.
Specified pressure ratio $\frac{14.7 + 4.5}{14.7}$	= 1.306
Pressure ratio on test $\frac{29.6 + 9.68}{29.6 - 0.172} = \frac{39.28}{29.428}$	= 1.335
From Fig. 2 $\frac{T_f}{T_0}$	= 1.088
$\therefore t_a = (1.088 \times 528.24) - 461$	= 113.74
Internal adiabatic efficiency $\frac{t_a - t_0}{t_f - t_0} = \frac{113.74 - 67.24}{132.4 - 67.24} = \frac{46.5}{65.16}$	= 71.3 per cent.
Pressure before 13-in.-dia. nozzle	4.6 in. Hg.
Temperature before 13-in.-dia. meter nozzle	127.27 deg. F.
$\therefore P_a = 29.6 + 4.6$	= 34.2 in. Hg.

Fig. 13.

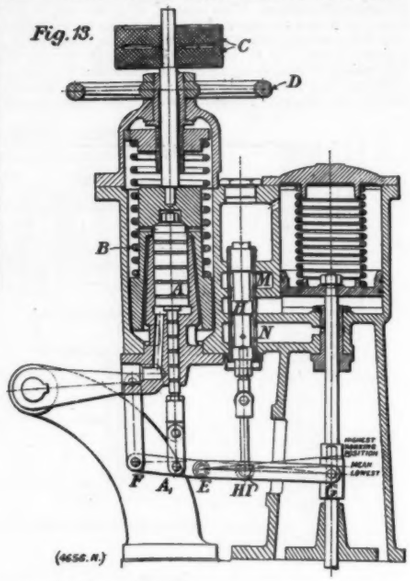


Fig. 12.

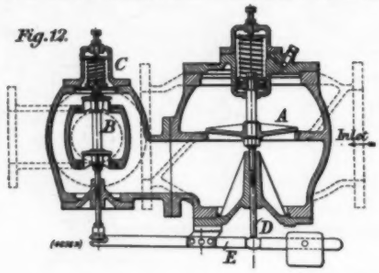


Fig. 14. TYPICAL TURBO-COMPRESSOR INSTALLATION.

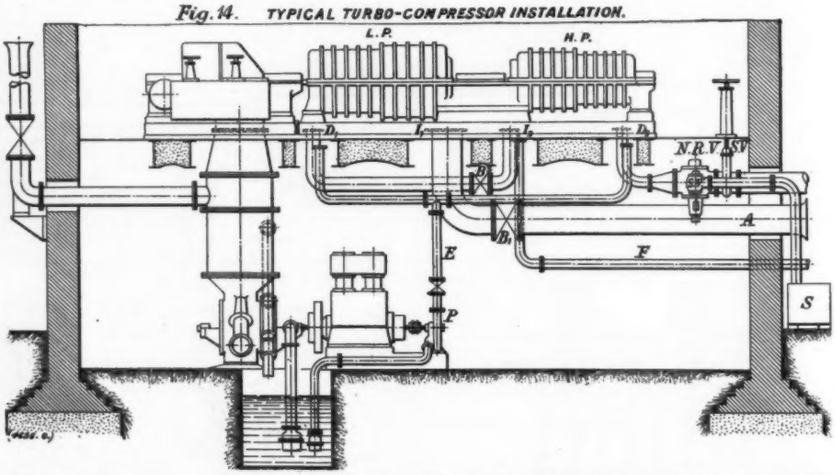
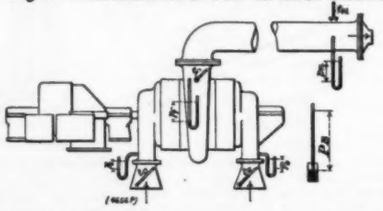


Fig. 15. ARRANGEMENT OF TEST ON TURBO-BLOWER.



and

$$\frac{P_n}{P_0} = \frac{34.2}{29.6} = 1.1555.$$

∴ From Fig. 20, free-air discharge

$$= 8690\left(\frac{13}{7}\right)^2 \times 0.912^* \times \frac{29.6\dagger}{30} = 26{,}900 \text{ cub. ft. per min.}$$

From Fig. 16—

$$\text{B.H.P.} = 185 \times 1.072 \times \frac{26{,}900}{10{,}000} \times \frac{100}{71.3} = 748 \text{ B.H.P.}$$

Steam cons. corr. to 155 lb. per sq. in. g. dry sat. 27½ in. vacuum ... ... = 10,418 lb. per hour

Corr. steam quantity at 155 lb. per sq. in. g. dry sat. 27½ in. vacuum for 26,000 cub. ft. free air compressed to 4½ lb. per sq. in. g.... ... ... = 9,083 lb. per hour

Steam per 1000 cub. ft. of free air... ... ... = 5.82 lb.

The method of stating blower performance and guarantees which is used in the last line is a useful one to adopt,

Fig. 16. WORK DONE IN ADIABATIC COMPRESSION.

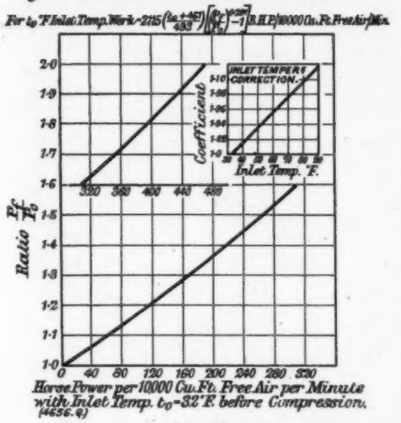

For t_0 °F Inlet Temp. Work = 2115 $\left(\frac{t_0+461}{493}\right)\left[\left(\frac{P_f}{P_0}\right)^{0.283}-1\right]$ B.H.P./10000 Cu. Ft. Free Air/Min.
Ratio $\frac{P_f}{P_0}$
Coefficient
INLET TEMPERATURE CORRECTION.
Inlet Temp. °F.
Horse Power per 10000 Cu. Ft. Free Air per Minute with Inlet Temp. t_0 = 32° F. before Compression.
(4656.c)

Fig. 18. WORK DONE IN ISOTHERMAL COMPRESSION OF AIR.

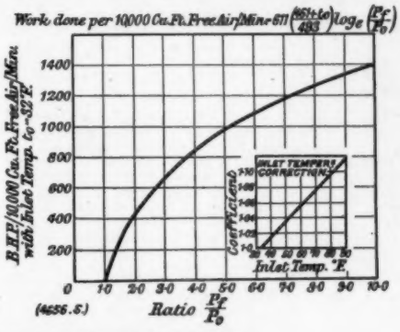
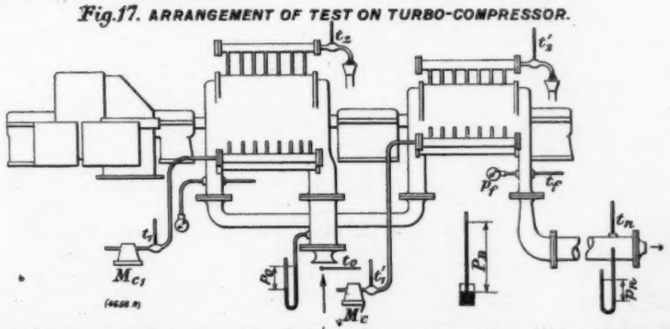

Work done per 10000 Cu. Ft. Free Air/Min. = 671 $\left(\frac{461+t_0}{493}\right)\log_e\left(\frac{P_f}{P_0}\right)$
B.H.P./10000 Cu. Ft. Free Air/Min. with Inlet Temp. t_0 = 32° F.
Coefficient
INLET TEMPERATURE CORRECTION.
Inlet Temp. °F.
(4656.b)
Ratio $\frac{P_f}{P_0}$

Fig. 17. ARRANGEMENT OF TEST ON TURBO-COMPRESSOR.



especially when the same manufacturer supplies both turbine and blower.

Commercial Tests on Compressors.—The remarks relating to the general consideration of blower tests apply equally to tests on compressors.

In order to calculate the volume of air discharged the following readings must be taken :—

t_n = The temperature before the discharge nozzle in deg. Fahr.

p_n = The pressure before the discharge nozzle in inches Hg. measured by a Pitot tube.

The volume drawn into the compressor can be calculated from the following readings (see Appendix) :—

t_0 = The temperature before the suction nozzle in deg. Fahr.

p_0 = The suction pressure after the nozzle in inches Hg.

The difference between the volumes of air drawn into the compressor and that discharged represents the leakage at the glands. The horse-power and efficiency of the compressor can be calculated by the aid of Fig. 18 if the following readings are taken :—

M_{c1} = The cooling water to first casing in pounds per second.

t_1 = The inlet temperature of cooling water to first casing in deg. Fahr.

t_2 = The outlet temperature of cooling water from first casing in deg. Fahr.

M_{c2} = Cooling water to second casing in pounds per second.

t'_1 = Inlet temperature of cooling water to second casing in deg. Fahr.

t'_2 = Outlet temperature of cooling water from second casing in deg. Fahr.

t_0 = Temperature of free air.

p' = Pressure after suction nozzle in inches Hg.

t_f = Temperature of air leaving the compressor in deg. Fahr.

p_f = Pressure of air leaving the compressor in pounds per square inch.

When calculating the isothermal horse-power in cases where a nozzle is used on the compressor suction, it should be noted that the ratio of compression when all pressures have been reduced to pounds per square inch is

$$\frac{P_f}{P_0} = \frac{P_n + p_f}{P_n - p'}.$$

The speed of the compressor in revolutions per minute and both the temperature and pressure after the first cylinder should also be noted. The inlet temperature correction and the pressure ratio correction for power apply equally to blowers and compressors.

The following official test results were obtained on one of two compressors which have been supplied by the British Westinghouse Company to the New Hucknall Colliery Company, and are given here as an illustration of the preceding remarks. The compressor was driven by a high-pressure turbine :—

Duration of test	...	80 minutes
Barometer at 32 deg. Fahr.	...	29.9 in. Hg = 14.65 lb. per sq. in.
Temperature of free air	...	70.52 deg. F.
Speed shown on tachometer	...	4100 R.P.M.
Pressure at compressor inlet	...	9.03 vac. ins. W.G. = 0.664 in. Hg.
Temperature at compressor inlet		70.52 deg. Fahr.
Final pressure	...	78.4 lb. per sq. in. g.

Pressure ratio—

$$\frac{78.4 + 14.65}{14.65 - 0.664} = \frac{93.05}{13.986} = 6.653.$$

Guaranteed pressure ratio—

$$\frac{80 + 14.7}{14.7} = 6.442.$$

Final temperature	... ...	192.74 deg. Fahr.
Pressure before 7-in.-dia. nozzle		59.67 in. W.G. = 4.38 in. Hg.
Temperature before 7-in.-diameter nozzle	... ...	165.38 deg. Fahr.

∴ $P_n = 29.9 + 4.38 = 34.28$ in.

$$\therefore \frac{P_n}{P_0} = \frac{34.28}{29.9} = 1.1465.$$

∴ From Fig. 20 free air discharge

$$= 8420 \times 0.887 \times \frac{29.9}{30} = 7450 \text{ cub. ft. per min.}$$

Steam cons. corr. to 80 lb. per sq. in. g. dry sat. 27½-in. vac. = 23,107 lb. per hr.

∴ Total steam cons. corr. to specified steam conditions and 7500 cub. ft. per minute free air at 80 lb. per sq. in. ... = 22,437 lb. per hour

∴ Steam per 1000 cub. ft. =

$$\frac{22{,}437 \times 1000}{7500 \times 60} = 50 \text{ lb.}$$

The authors wish to express their indebtedness to the management of the British Westinghouse Company for permission to use information which has been largely acquired in their employ, and for the loan of blocks illustrating the machines they have built, also for particulars of test results on these machines.

APPENDIX.

Measurement of Air Quantity.—The most convenient and accurate method of measuring large air quantities consists in discharging into the free atmosphere through a standard convergent nozzle such as that shown in Fig. 19. Care must be taken that the air approaches the nozzle in a steady, uniform stream. It is only necessary to measure the temperature and pressure before and after the nozzle in order to be able to calculate the volume of air passing through it.

If

P B = Barometric pressure measured in inches Hg.

p_n = Pressure before the nozzle in inches Hg. by a Pitot tube.

P_n = P B + p_n = absolute pressure before the nozzle.

P′ = Absolute pressure after the nozzle measured in inches Hg. = $P_n - p'$.

F = Area of throat of nozzle in square feet.

t_n = Temperature before nozzle in deg. Fahr.

T_n = 461 + t_n.

λ = 1.41 for air.

R = Constant air P V = R T = 53.3 for air.

μ = Coefficient of discharge nozzle.

g = 32.2 ft.-sec. per second.

V = Specific volume in cubic feet per pound in the conditions at the throat of the nozzle.

V′ = Specific volume of free air in cubic feet per pound = 13.08 cub. ft. per lb.

Fig. 19. STANDARD MEASURING NOZZLE.

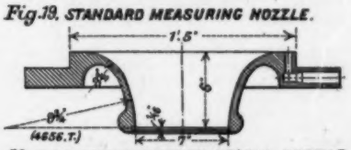
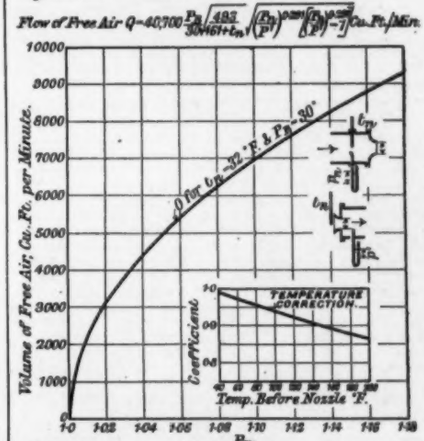


Fig. 20. FLOW OF AIR THROUGH A 1″ DIA. NOZZLE.


Flow of Free Air $Q = 40{,}700 \frac{P_n}{30}\sqrt{\frac{493}{461+t_n}}\sqrt{\left(\frac{P_n}{P'}\right)^{0.286}\left[\left(\frac{P_n}{P'}\right)^{0.286}-1\right]}$ Cu. Ft./Min.
Volume of Free Air, Cu. Ft. per Minute.
0 for t_n = 32° F. & P_n = 30"
TEMPERATURE CORRECTION.
Coefficient
Temp. Before Nozzle °F.
(4656.u)
Ratio $\frac{P_n}{P'}$

The expansion in the nozzle may be considered to take place adiabatically, and since no external work is done, the process which takes place is simply a conversion of some of the potential energy of the air into kinetic energy.

Assuming that the air-main before the nozzle is so large that the velocity in it can be neglected, we get that the velocity of discharge $C_d = \sqrt{2\,g\,J\,C_p\,(T_n - T')}$ feet per second, and making the substitution P V = R T :—

$$C_d = \sqrt{2\,g \cdot \frac{\lambda}{\lambda - 1} \cdot (P_n V_n - P' V')} \text{ feet per second.}$$

The volume (in cubic feet) of free air discharged per minute

$$= \mu F V' P' 60 \sqrt{\frac{2\,g}{R\,T_n} \cdot \frac{\lambda}{\lambda - 1} \cdot \left(\frac{P_n}{P'}\right)^{\frac{\lambda-1}{\lambda}} \left\{\left(\frac{P_n}{P_0}\right)^{\frac{\lambda-1}{\lambda}} - 1\right\}}$$

The coefficient of discharge has been measured for such a nozzle as that shown in Fig. 19 and found to be between 1.0 and 0.99. In what follows the value μ = 1.0 has been used ; the correction for any other value will be obvious. With a nozzle having a throat 7 in. in diameter the volume (in cubic feet per minute) of free air discharged

$$= 40{,}700\left(\frac{P\,B}{30}\right)\sqrt{\frac{493}{461 + t_n}}$$

$$\sqrt{\left(\frac{P_n}{P'}\right)^{0.291} \cdot \left\{\left(\frac{P_n}{P_0}\right)^{0.291} - 1\right\}}.$$

This has been plotted in Fig. 20 for the nozzle discharging into free atmosphere with $P_0 = P_n = 30$ in. Hg., and $t_n = 32$ deg. Fahr. If during the test the barometer is P_n inches Hg., and the temperature before the nozzle is

* Temperature correction. † Barometer correction.

t_n deg. F. the volume read from Fig. 20 must be multiplied by

$$\frac{P_n}{30}\sqrt{\frac{493}{461+t_n}},$$

the second factor of which is plotted as a temperature correction in Fig. 20. It is sometimes convenient to measure the air quantity by aspirating the air through a nozzle placed at the inlet side of the machine. In such a case the volume of air passing through the nozzle can be obtained from Fig. 20, p_n now being equal to the barometric pressure P_n; and if p_n is the pressure indicated by a static tube placed after the nozzle, P' is equal to $(P-p)$. It should be added that the above formula and the curve deduced from them do not hold if the ratio $\left(\frac{P_n}{P'}\right)$ is greater than 1.9.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

South Africa: With reference to the scheme for the disposal of sewage in the suburbs of Cape Town, H.M. Acting Trade Commissioner in South Africa reports that a notice has appeared in the local Press to the effect that the Cape Town Corporation proposes to obtain the sanction of the ratepayers to the raising of a loan of 500,000*l.* for the purpose of carrying out the scheme.

New Zealand: H.M. Trade Commissioner in New Zealand has forwarded an extract from the local Press, from which it appears that plans have been approved by the Dominion Government for the carrying out of hospital extensions at Auckland, at an estimated cost of 21,000*l.* The proposed extensions comprise a children's ward at the Auckland Hospital, to cost 16,000*l.*, and the addition of a first-floor ward to the infirmary ward of the Costley Home, Epsom, to cost 5000*l.* It has also been decided to proceed with the erection of a cottage hospital at Warkworth.

Portugal: The *Diario do Governo*, Lisbon, publishes a notice approving the project for the construction of the second section, 22 km. (about 13¾ miles) long, of the Vale do Tâmega Railway—viz., between Amarante and Freixiero. The estimated cost of the undertaking is 555,560 escudos (about 78,700*l.*).

Spain: The *Gaceta de Madrid* notifies that sealed tenders were to be received at the Negociado Quinto de la Segunda Sección (Material) del Estado Mayor Central de la Armada, Ministerio de Marina, Madrid, up to 1 p.m. on February 9, for the supply and installation of a crane, and the laying of ways and paving in the Victoria Eugenia Dock at the Naval Arsenal at Ferrol. The estimated cost of the works is put at 527,068 pesetas (about 21,000*l.*). The *Gaceta* also notifies that tenders will be opened by the Municipal Authorities at Málaga, on February 22, for the construction of a market at that town. The estimated cost of the undertaking is 92,447 pesetas (about 3700*l.*). The *Gaceta* further notifies that tenders will be received by the Municipal Authorities at Barcelona, within a period of thirty days from January 21, for the execution of improvements and extensions to a municipal building in the San Andres district of Barcelona. The estimated cost of the works is 87,357 pesetas (about 3500*l.*). The contract includes the supply of masonry, woodwork, metal fittings, glass, paints, &c.

Argentina: The *Boletin Oficial*, Buenos Aires, notifies that tenders are invited by the National Sanitation Department of the Argentine Ministry of Public Works for the supply of machinery for the town of Santa Fé, in accordance with the specifications and conditions of tender available for inspection at the technical section of the department, Calle Charcas 1840, Buenos Aires. Tenders will be received at the Secretaria del Directorio de las Obras Sanitarias de la Nacion, Buenos Aires, up to 3 p.m., on April 24 next. Local representation is necessary.

Western Canada.—The provinces of Manitoba, Saskatchewan, and Alberta, bounded east by the Great Lakes, and on the west by the Rocky Mountains, are being settled by Canadians and immigrants from all over the world, and they offer inducements for the investment of capital in farm mortgages. The vast stretch of country included in the three provinces comprises 466,068,798 acres, of which about 45 per cent. is suitable for cultivation; twenty years ago this great territory was only sparsely settled. The crop yield of all grain in Western Canada in 1900 was 54,120,400 bushels, as compared with crop estimates for 1915—prepared by the North-West Grain Dealers' Association and the Dominion Government—of 663,788,000 bushels. It should be added that, so far as threshing operations have proceeded, the 1915 estimates are found to be, if anything, below the mark. From 1908 to 1914 inclusive the railway mileage in the three provinces showed an increase of 5000 miles; but even with this large increase, the railways of Western Canada are being taxed to their utmost strength to handle the large crop of 1915. There still remains a vast tract of land which will accommodate a very large number of settlers, and absorb a great further amount of capital. Last year the United States took about 43 per cent. of all Canadian bonds sold, and this is, of course, strong evidence of the faith which American investors have in the Canadian future.

CATALOGUES.

Portable Telephones.—Messrs. James McMillan and Co., of Clun House, Surrey-street, Strand, W.C., have issued an illustrated catalogue giving prices and full particulars of portable telephones and accessories for field telephony on military service, rifle-ranges, &c.

Dynamos and Motors.—Lists giving particulars of direct-current and single-phase motors, and polyphase motors and generators in stock for immediate delivery, have reached us from the Swedish General Electric, Limited, whose London office is at Canada House, Kingsway, W.C.

Electric Heating and Cooking Apparatus.—A small catalogue, giving prices and particulars of radiators, ovens, hot-plates, kettles, flat-irons, soldering-irons, and other electric heating and cooking apparatus, has come to hand from the Dowsing Radiant Heat Company, Limited, of 39 and 40, York-place, Baker-street, W.

Motor-Starting and Control-Gear.—Messrs. Brook, Hirst and Co., Limited, of Northgate Electrical Works, Chester, have issued a very useful catalogue of ironclad hand-operated starters and controlling panels for direct-current motors, ranging from ¼ to 450 horse-power, and from 100 to 550 volts. Prices, dimensions and shipping particulars are given of all the apparatus dealt with.

Petrol-Driven Pumps.—The British Steel Piling Company, of Dock House, Billiter-street, E.C., has issued a catalogue giving prices of "Zenith" petrol-driven centrifugal pumps suitable for unwatering foundations, draining trenches, emptying cesspools, dredging, and other contractors' work, as well as for irrigation and general service. Full particulars are given of sets with engines ranging from 2 to 24 horse-power, but larger sizes can be supplied.

Welded Boilers.—A useful catalogue, giving prices and particulars of welded boilers in wrought-iron and steel, has come to hand from Messrs. Robert Jenkins and Co., of Rotherham. The catalogue includes all shapes and sizes of boilers for kitchen ranges, as well as sectional, cylindrical, box, saddle, and other types of boilers for heating apparatus, and for hot-water supply. Steam-jacketed pans, pipes and connections, furnace fronts, steel and copper cylinders, and copper boilers, are also dealt with.

Hydraulic Turbines.—We have received from Messrs. Pitman, César and Co., of 25, Victoria-street, Westminster, S.W., a catalogue of Pelton wheels and Francis turbines constructed by them. Tables giving the water consumption, horse-power, and speed of the different sizes made in each class of turbine, are included in the catalogue, and some typical installations are illustrated. Small water-motors of the Pelton-wheel type, suitable for charging accumulators, driving dental lathes, ventilating-fans, and other light machinery, are also dealt with.

Paper Pinions.—A price-list of compressed-paper pinions has come to hand from Sir W. G. Armstrong, Whitworth and Co., Limited, of Openshaw, Manchester. Prices are stated for pinions ranging from 2½ in. in diameter by 1-in. face to 20 in. in diameter by 12 in. face. The principal advantages claimed for these pinions are that they give a silent and efficient drive at a cost not exceeding that of raw-hide pinions, that the uniformity of the teeth is maintained in service, that a little graphite is the only lubricant required, and that they are unaffected by atmospheric conditions.

Steam-Pumps.—We have received from Messrs. Willans and Robinson, Limited, of Rugby, a catalogue relating to the Willans-Oddie steam-pumps constructed by them. These pumps are of the simplex direct-acting type, and their special feature is the steam-distributing valve. The catalogue illustrates and describes the valve-gear and points out its advantages, claiming for it exceptional simplicity, durability, reliability, and efficiency. Particulars are also given of the standard sizes made for boiler-feeding, hydraulic, and general services. Some information on the working of the pumps, and a list of spare parts, are also included.

Balata Belting.—A price-list of "Pylata" brand balata belting has come to hand from Messrs. T. H. Haagen, Son and Co., of Horselydown Works, Tower Bridge, London, S.E. This belting is woven solid from very fine cotton yarns, so that there are no plies to separate, as there are with ordinary balata belting. It is also claimed to have great tensile strength, combined with freedom from stretch, and to give increased grip, owing to the special formation of the driving-face. The belts are stated to be waterproof and to work satisfactorily in any temperature, and they are also claimed to withstand the wear of the forks as well as leather belts. "Pylata" belts are made in eight strengths, corresponding to ordinary balata belts with from three to ten plies, and prices are stated for belts ranging from 1 in. to 40 in. in width. A code-word is assigned to each width and strength to facilitate ordering by telegraph.

Tungsten-Arc Lamps.—We have received from the Edison and Swan United Electric Light Company, Ltd., of Ponders End, Middlesex, a circular relating to their new "Pointolite" lamp. In this lamp, which is the tungsten-arc lamp described on page 575 of our issue of December 3 last, the source of light is a small ball of tungsten, which, on account of its small size and high intrinsic brilliancy, forms an almost ideal illuminant for optical purposes. Only one size of lamp, suitable for use in an ordinary projection lantern, is made at present, and this gives 100 candle-power at an efficiency of 0.65 watt per mean spherical candle-power. It is supplied with a standard resistance-box for use on direct-current circuits ranging from 100 to 250 volts, but special resistances can be supplied for any voltage. Other lamps of this type for use in kinematograph lanterns and searchlights, as well as for photographic and other technical purposes, are in preparation.

Rotary Blowers and Exhausters.—The Sturtevant Engineering Company, Limited, of 147, Queen Victoria-street, E.C., have sent us a copy of their latest catalogue of rotary blowers and exhausters. These blowers are largely used where it is necessary to produce a blast, or to exhaust, at pressures up to 5 lb. per sq. in. They are claimed to be exceptionally durable and reliable, owing to the fact that there is no internal contact between the rotors and the casing. Another important point in the design is that very little power is transmitted by the gearing connecting the rotors, since the whole of the work of compression is performed by the directly-driven rotor. The function of the gear-driven rotor is merely to allow the working parts of the main impeller to pass from the pressure to the suction side without allowing the compressed air to escape. The blowers are listed in 15 standard sizes, capable of delivering from 5 cub. ft. to 15,000 cub. ft. per minute at a pressure of ½ lb. per sq. in. They can be driven by steam-engines, electric motors, or by belt.

British Trade with Italy.—We have received from the British Chamber of Commerce for Italy, Genoa, a list, No. 23, giving a large number of openings for British articles in Italian markets.

The Financial Results of the German Machine Industry.—The following particulars, which have recently been made available, refer to the year 1913, the last normal year before the breaking out of the great war. They should comprise a total of 334 limited companies engaged in the manufacture of machines of diverse kinds, the nominal capital of these companies being 814,000,000 marks, but only 262 companies, with a capital of 723,000,000 marks, could be statistically dealt with, inasmuch as the following companies were left out:—Companies in a state of liquidation, or in bankruptcy; companies from which no report was obtainable; companies formed in 1913, but with regard to which no balance-sheet appeared till the following year; and, finally, companies which in the course of 1913 were writing down their capital. The list of companies dealt with in the following statistics, and those left out for the above specified reasons, is appended below:—

		Nominal Capital. Marks.	Per Cent.
Companies included	262	723,418,645	89
With no or incomplete balance-sheet	43	62,068,000	8
In process of writing-down capital	6	9,287,000	1
Companies whose balance-sheet first appeared in 1914	1	1,000,000	
Companies in liquidation ..	19	14,906,600	2
Companies in bankruptcy ..	3	3,100,000	
	334	813,780,245	100

It will appear from the above list that during the year 1913 there were altogether 312 companies in operation, with a share capital of 796,000,000 marks.

The balance-sheets referred to financial years ended:—

				Marks.
March 31, for 25 companies, with capital			..	53,925,000
June 30	,, 81	,,	..	251,558,530
Sept. 30	,, 38	,,	..	68,597,600
Dec. 31	,, 97	,,	..	291,090,800

whilst 21 companies terminated their financial year at other dates, the capital of such companies amounting to a total of 58,246,715 marks. In the balance-sheet year 1913, 282 limited companies, with a nominal capital of 723,000,000 marks, have been examined, whereas the actual capital in the concerns, principally emanating from the shareholders, amounted to 983,000,000 marks. The latter total is thus rather more than one-third higher than the nominal share capital. The original share capital was 374,000,000 marks, which, with a present nominal share capital of 723,000,000 marks, shows an increase of 48.3 per cent. Amongst the 262 limited companies with which this survey deals, 212 limited companies, with a nominal capital of 608,000,000 marks, had fixed debts (mortgages, debentures, &c.) amounting in the aggregate to 262,000,000 marks. The genuine reserves of these 262 companies amounted to 202,000,000 marks. The capital of these companies thus amounts to 925,000,000 marks, and the actual working capital to 1,187,000,000 marks. Of the 262 companies 142 companies are quoted on the Exchange. The following table shows the various dividends paid by the companies that are dealt with here during the year 1913:—

Dividend. Per Cent.	Nominal Share Capital. Marks.	Dividend. Per Cent.	Nominal Share Capital. Marks.
0	92,000,000	10	41,000,000
2	2,000,000	11	19,000,000
3	14,000,000	12	37,000,000
4	40,000,000	14	17,000,000
5	50,000,000	16	69,000,000
6	50,000,000	18	12,000,000
7	22,000,000	21	35,000,000
8	137,00,0000	25	27,000,000
9	56,000,000	28	2,000,000

Altogether 210 companies, which have paid a dividend during 1913, having a nominal capital of 631,000,000 marks, have paid an aggregate sum in dividends of 65,000,000 marks, which means an average of 10.3 per cent.